Herschel/Planck

SPIRE Detectors

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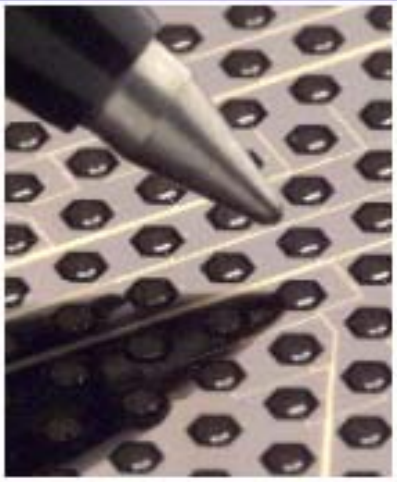
Agenda

- Science Overview
- Instrument Overview
- Requirements
- Action Item status
- Development Status
- Risk Status
- Programmatics

JPL Contribution Objective

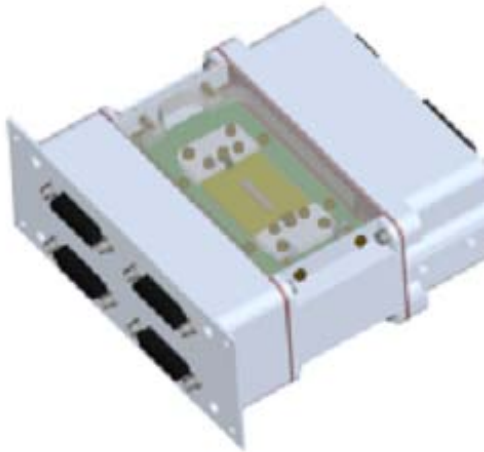
Objective: Design, development and delivery of Bolometer Detector Assembly (BDA), cold electronics and associated cabling.

Heart of detector subsystem: bolometer arrays. →



Typical BDA

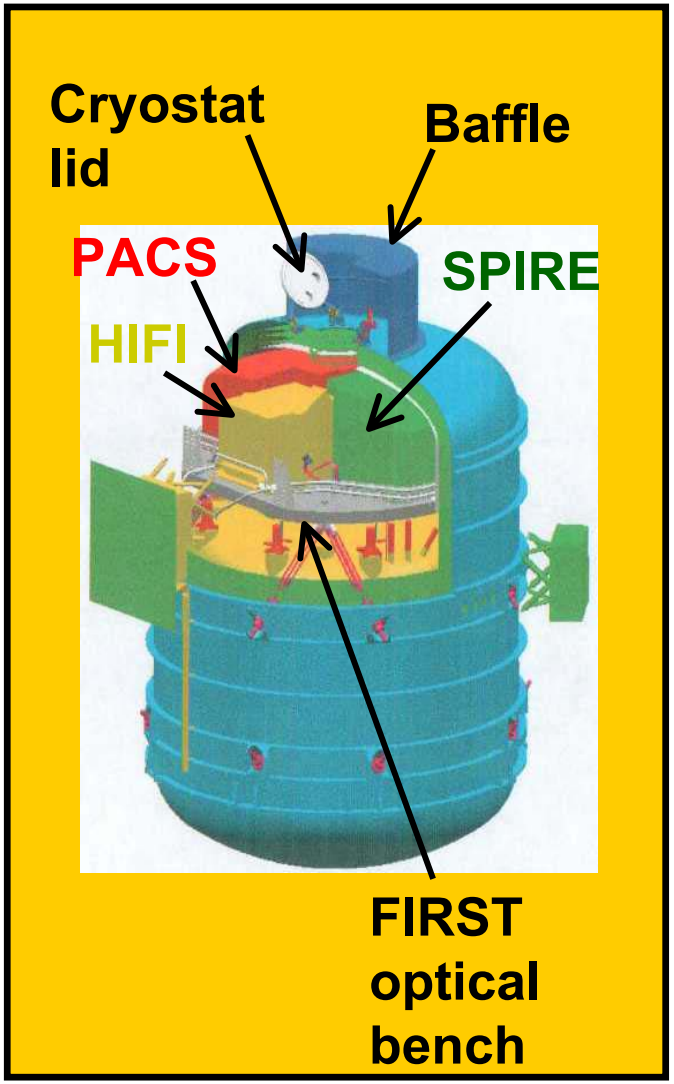
Item	Del. By	Rec. By
P/LW PFM BDA	JPL	RAL
P/MW PFM BDA	JPL	RAL
P/SW PFM BDA	JPL	RAL
S/LW PFM BDA	JPL	RAL
S/SW PFM BDA	JPL	RAL
8 JFET PFM modules	JPL	RAL
12 RF modules for FPU	JPL	RAL
BDA-JFET Harness	JPL	RAL
Back Harnesses for JFET rack	JPL	RAL
Temperature Control[11]	JPL	RAL



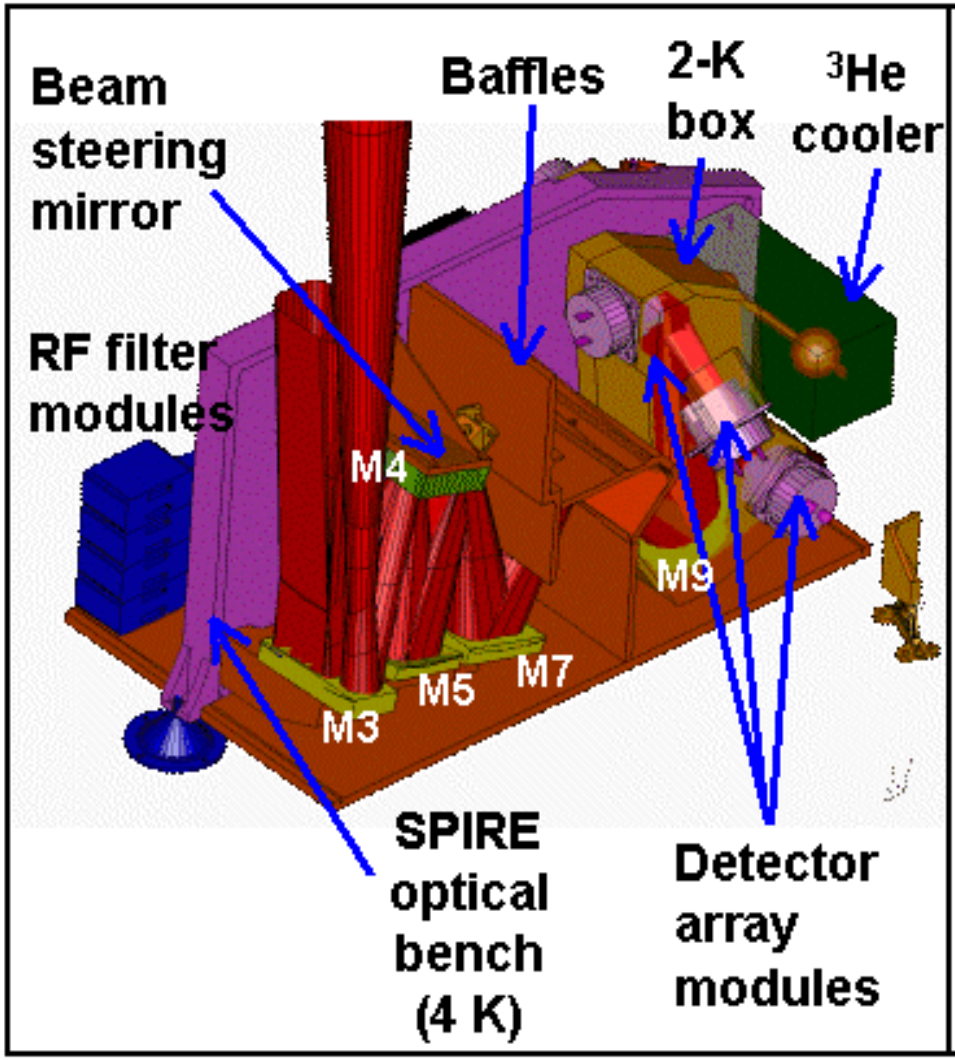
Typical JFET Module

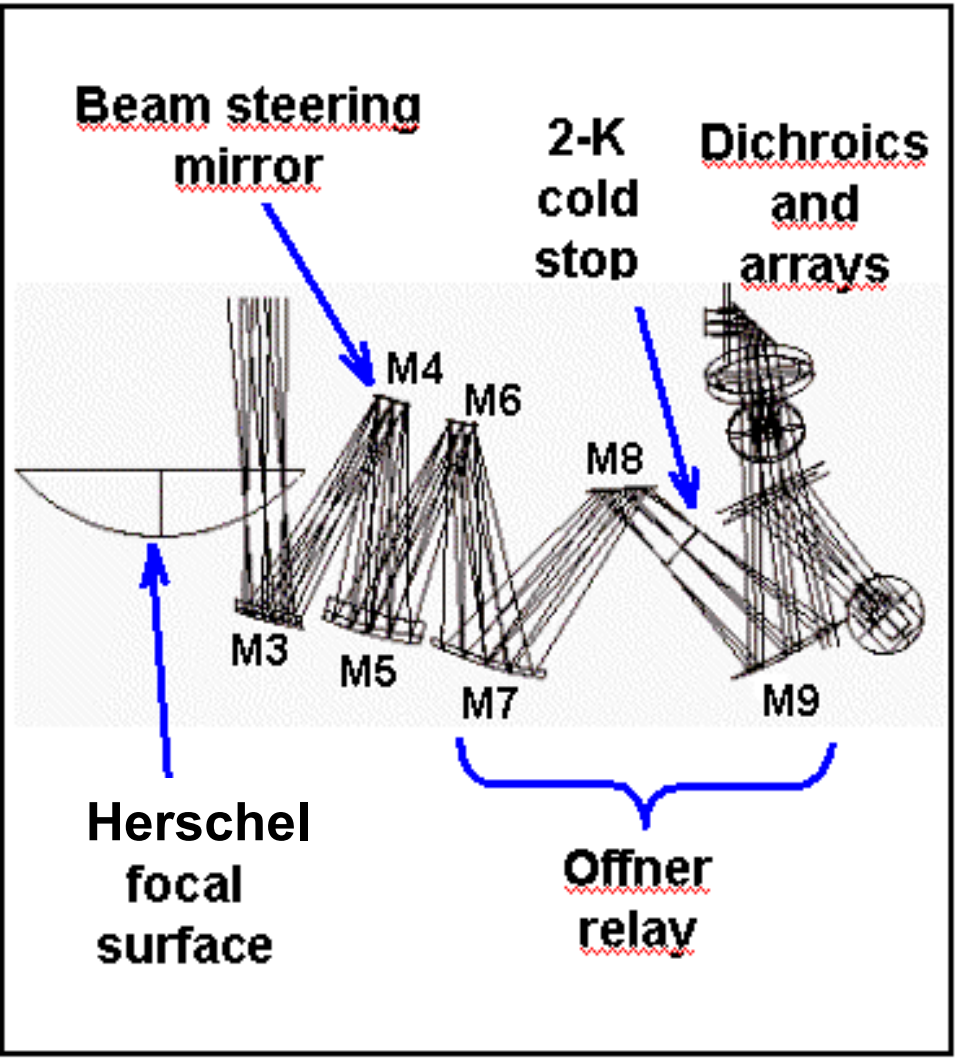
SPIRE Instrument Summary

- **3-band imaging photometer**
  - 250, 350, 500 μm (simultaneous)
  - λ/Δλ ~ 3
  - 4 x 8 arcminute field of view
  - Diffraction limited beams (17, 24, 35")
- **Imaging Fourier Transform Spectrometer (FTS)**
  - 200 - 400 μm (goal 200 - 670 μm)
  - > 2 arcminute field of view
  - $\Delta\sigma$ = 0.4 cm^{-1} (goal 0.04 cm^{-1}) (λ/Δλ ~ 20 - 100 (1000) at 250 μm)
- **Design features**
  - Sensitivity limited by thermal emission from the telescope (80 K; ε = 4%)
  - Feedhorn-coupled 'spider web' bolometers at 0.3 K
  - Minimal use of mechanisms
  - Simple observing modes

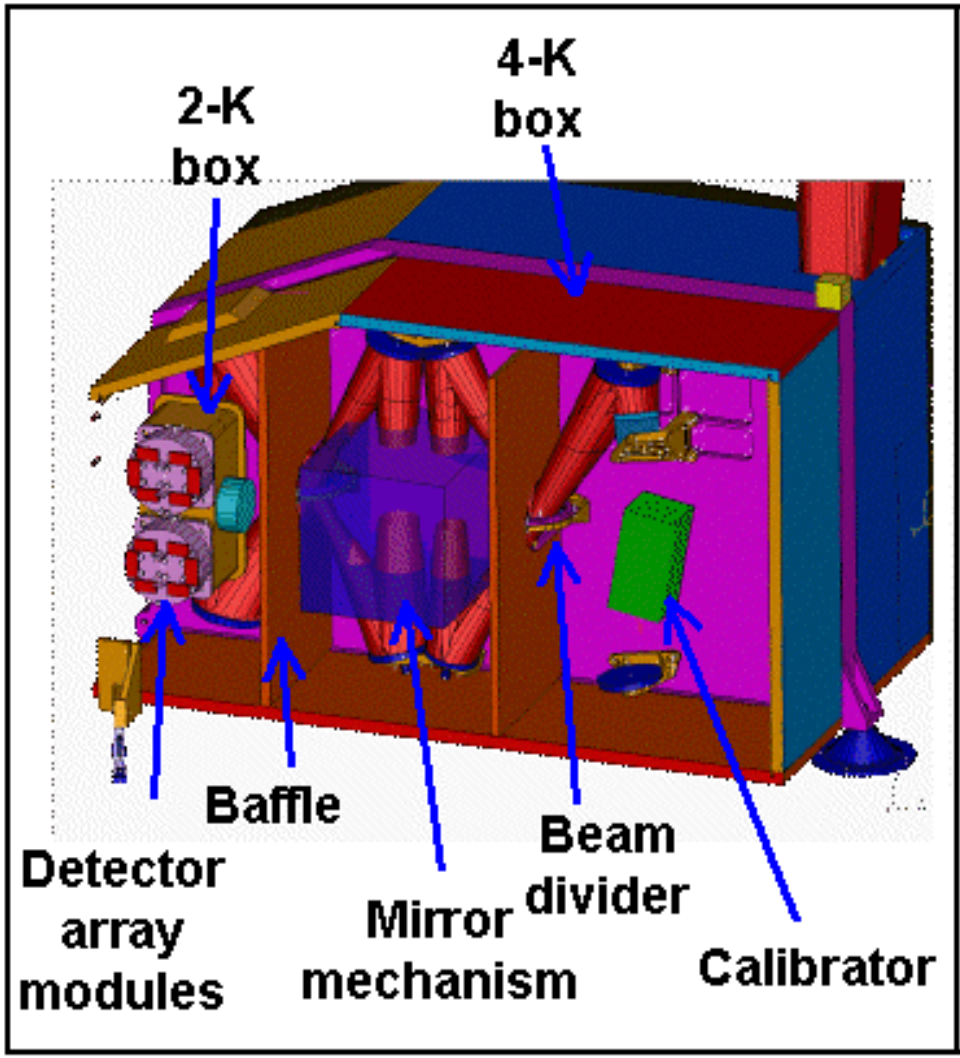


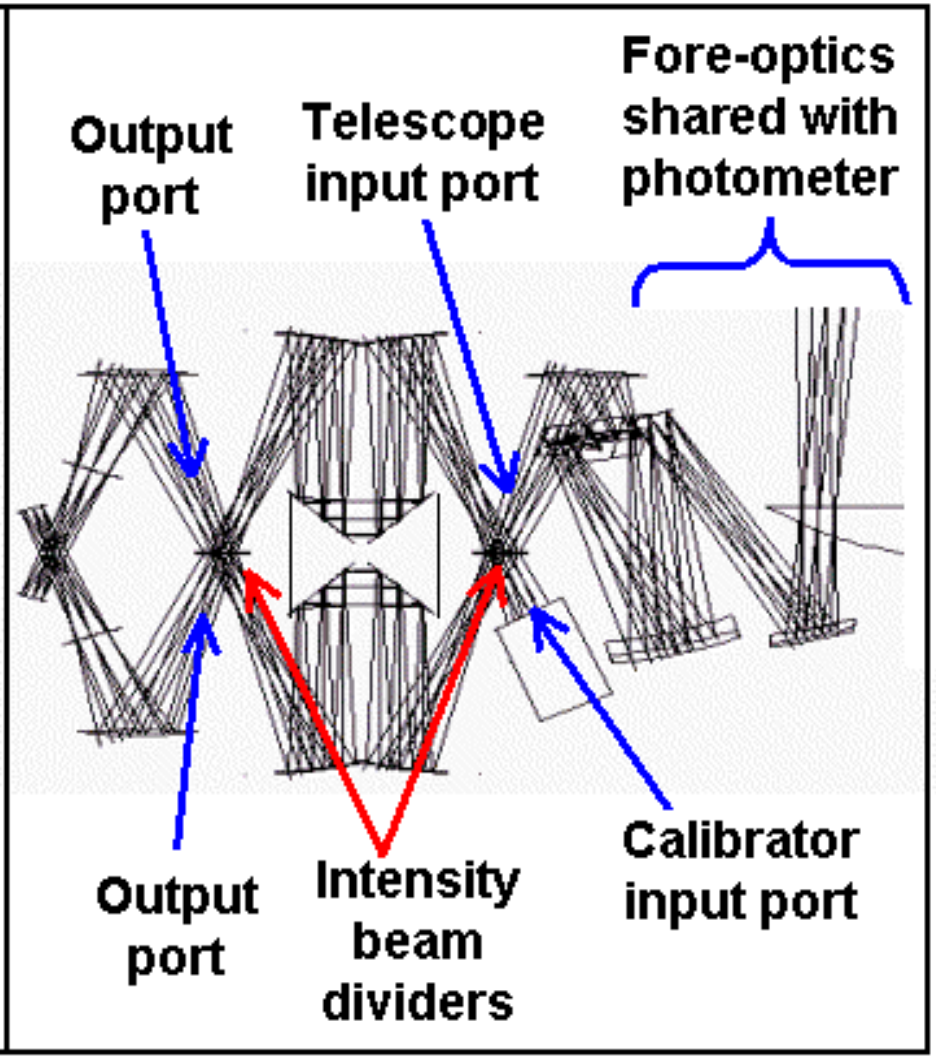
Photometer Layout and Optics



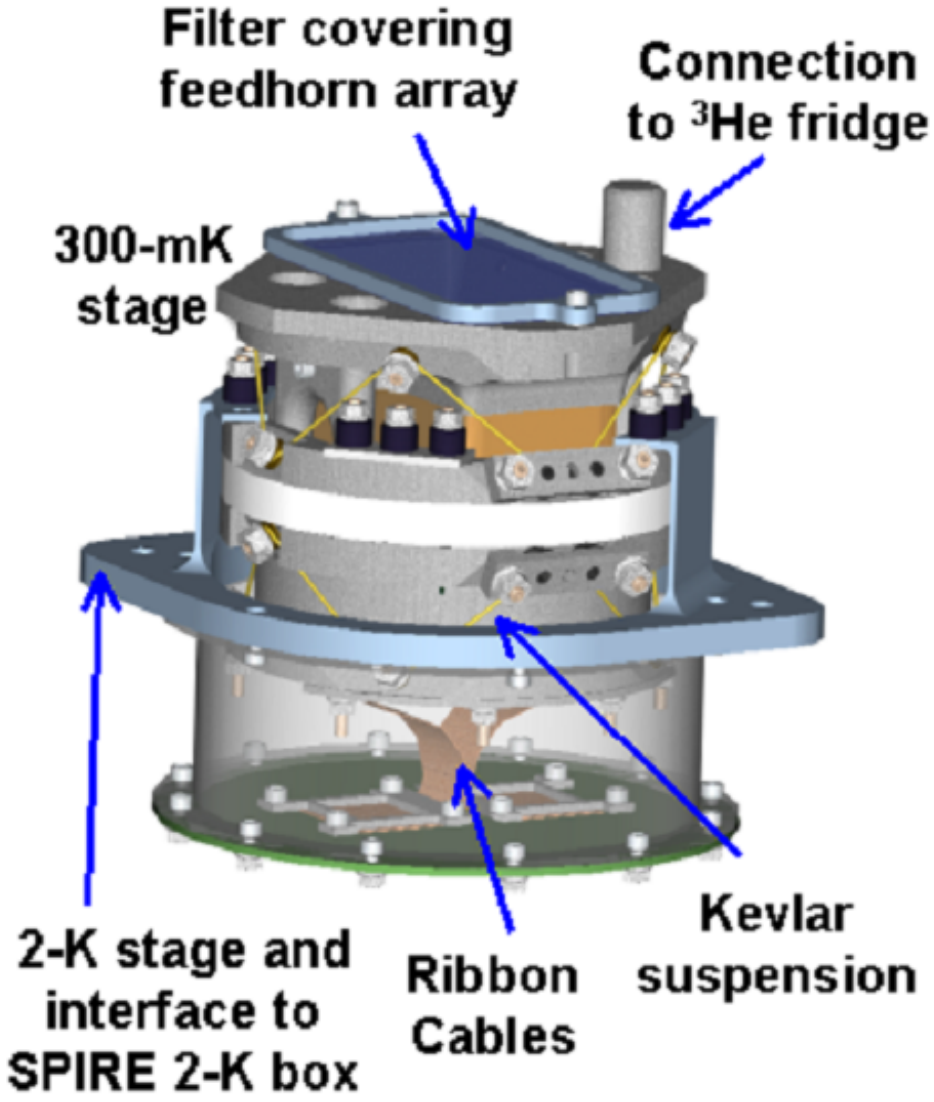


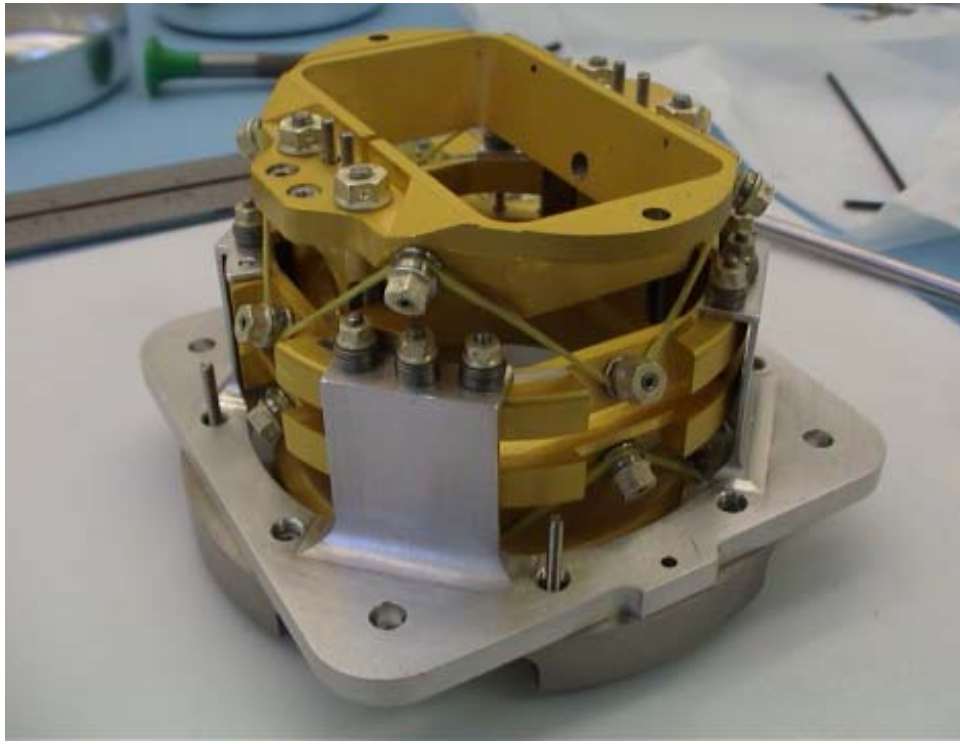
FTS Layout and Optics



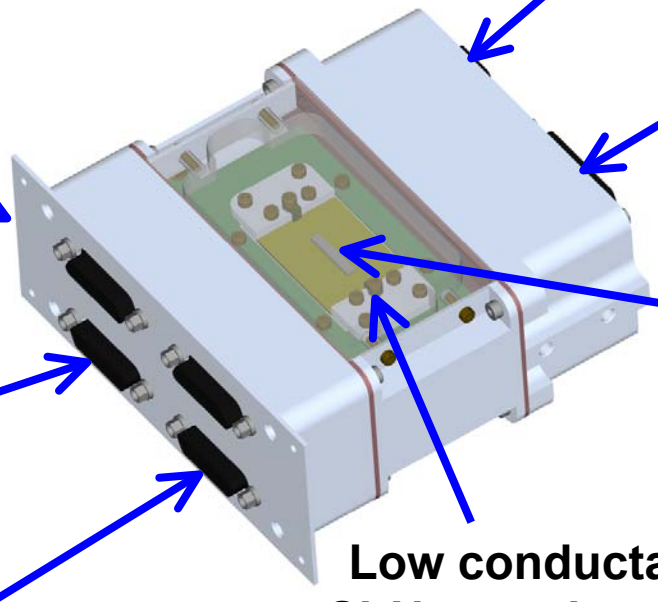


Bolometer Detector Assembly (BDA) Deliverable





JFET Module Deliverable



RF Filtered Power and Bias

Unfiltered Inputs
RF shielded cable to BDAs

Mounts to HOB at 10 K

Differential JFETs at ~130 K
Reduce output impedance from ~5 MΩ to ~5 kΩ

Electrical Interface
~7 m cable to warm electronics

RF Filtered Outputs

Low conductance Si_3N_4 membrane for thermal isolation
Conductance determines power dissipation

Model Philosophy

- **Engineering Model (EM) – Not delivered to RAL**
  - Each primary subsystem hardware deliverable has at least one engineering model that is a breadboard built and tested to confirm performance of key requirements
- **JPL Qualification Models (QM) – Not delivered to RAL**
  - Each primary subsystem hardware deliverable has one qualification model tested to qualification levels and durations as defined in the respective test plans
- **Structural Thermal Model (STM)**
  - This is an instrument model built at RAL with JPL supplied BDAs, harnesses and JFET Modules. This model is vibration tested and thermal cycled. The BDAs are comprised of one fully suspended unit and 4 structural/thermal simulators with no bolometer arrays.
- **Cryogenic Qual Model (CQM)**
  - This instrument is not environmentally tested but is used to verify performance at operating temperature. JPL supplies 3 functional BDA's and some other hardware detailed later in this presentation.
- **Proto-Flight Model (PFM)**
  - This is the instrument that flies and is acceptance tested.
- **Flight Spare Model (FSM)**
  - This instrument serves as the flight spare. JPL supplies a full complement of flight BDAs and associated hardware.

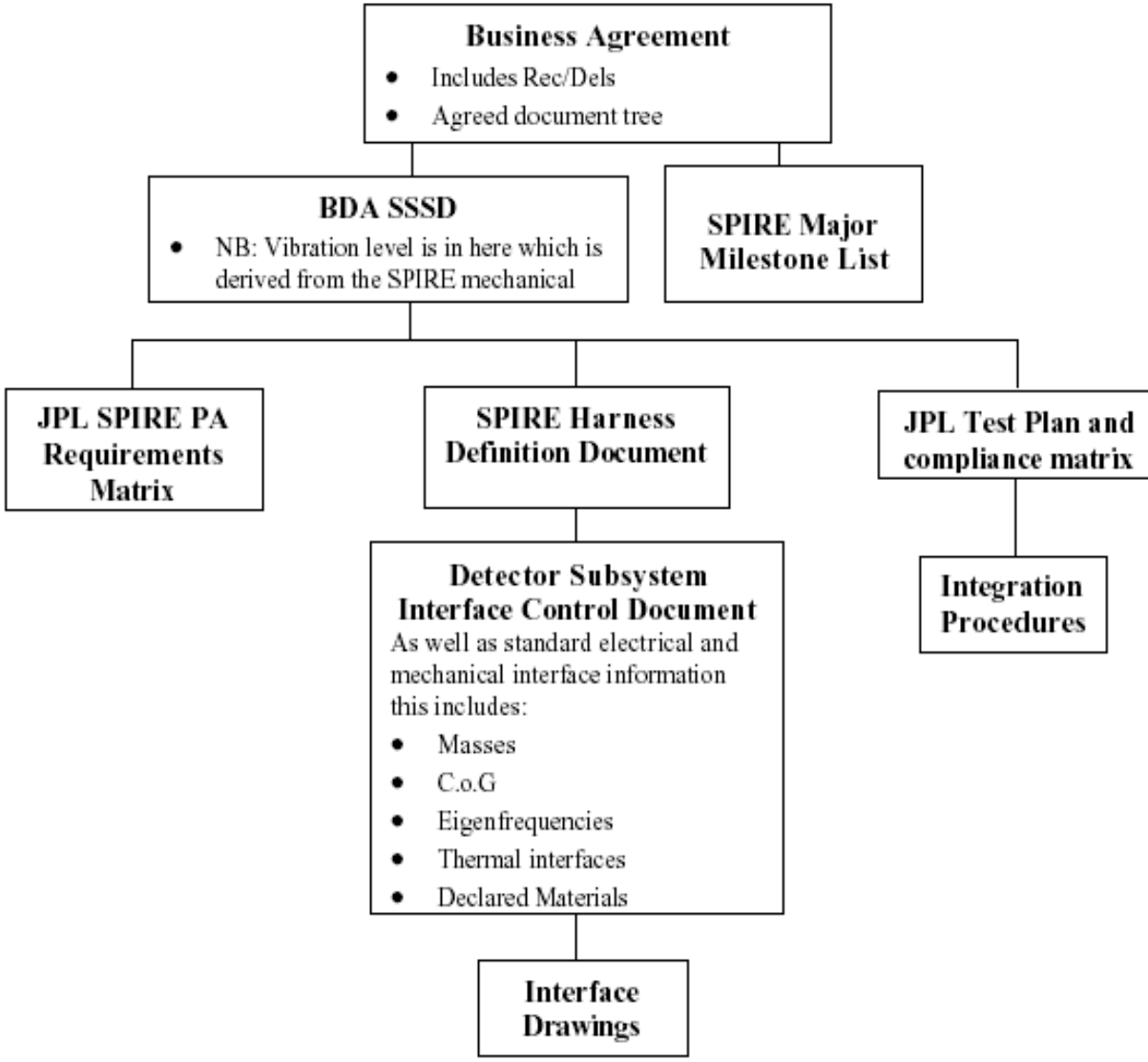
Hardware Delivered to RAL

- **Structural Thermal Model (STM)**
  - One kevlar suspended BDA unit; 4 structural/thermal equivalents; 8 JFET modules; 12 RF modules; 1 BDA/JFET harness; 1 Backharness
- **Cryogenic Qualification Model (CQM)**
  - 2 BDA's fully environmentally acceptance tested at JPL with dark and optical performance tests in the Cryogenic Testing Facility (BoDAC); 1 BDA workmanship tested only; 3 JFET Modules
- **Protoflight Model (PFM)**
  - 5 BDA's fully environmentally acceptance tested at JPL with dark performance tests in BoDAC; 8 JFET Modules; BDA-JFET harness; Back Harness; Temperature control hardware (if needed)
- **Flight Spare Model (FSM)**
  - 5 BDA's fully environmentally acceptance tested at JPL with dark performance tests in BoDAC (2 are refurbished CQM BDAs); 5 JFET Modules; Temperature control hardware (if needed)

Agreed-To Document Structure

- Agreed-to documentation with JPL and RAL signatories
- Business Agreement (BA) overarching document
- Subsystem Specification Document (SSSD) primary requirements document under BA (takes precedence over all other requirements documents)

Status: All documents (with exception of Harness Definition Document, Integration Document and STM ICD) have received full sign-off. Revisions implemented as needed.



Requirements Traceability by Category

Interface	Hardware Aspect	Agreed Documentation
Mechanical	BDA interface requirements	BDA-SSSD
	BDA I/F design	ICD
	JFET module I/F design	ICD
	RF module I/F design	ICD
Optical	BDA	ICD, BDA-SSSD
Thermal	BDA conduction	BDA-SSSD
	JFET dissipation	BDA-SSSD
	Thermal stability requirement	BDA-SSSD
Environmental	Vibration levels and temperature	BDA-SSSD
	Bake-out temperature	Test Plan
	EMI/EMC	BDA-SSSD
Harnesses	Cryoharness wiring	HDD
	Mechanical requirement	BDA-SSSD
	JFET-BDA harness routing	ICD
Electrical	DRCU performance	BDA-SSSD

Detector Performance and Flowdown

Bolometers designed to maximize mapping speed

Design values derived from:

- Approaching background-limited performance to within design limits
- Suitability of detectors for chopping, spectroscopy, and scan mapping

Minimum performance derived from:

- Achieved performance to date with margin

	P/LW		P/MW		P/SW		S/LW		S/SW		
$(NEP_{blip}/NEP_{total})^2$	0.66	0.55	0.73	0.61	0.79	0.66	0.73	0.61	0.79	0.66	
τ	18	32	13	32	11	32	4.2	14	4.2	8	[ms]
η_{opt}	0.85	0.45	0.85	0.45	0.85	0.45	0.85	-	0.85	-	
BDA yield	0.9	0.75	0.9	0.75	0.9	0.75	0.9	0.75	0.9	0.75	
JFET yield	0.9		0.9		0.9		0.9		0.9		
1/f knee	30	100	30	100	30	100	30	100	30	100	[mHz]
n-n cross-talk	1	5	1	5	1	5	1	5	1	5	[%]
Q	2.5		3.3		4.1		10.6		10.8		[pW]
JFET noise	7	15	7	15	7	15	7	15	7	8.5	[nV/√Hz]

Design value

Minimum performance based on prior testing

Mass, Power, and Alignment

	Achieved	Design	Requirement	Margin	
BDA average mass		510 g	600 g	17 %	
JFET mass		250 g	305 g	22 %	
RF filter mass		35 g	165 g	370 %	
Average BDA conduction from 1.7 K	1.0 μW (Kevlar, est'd) + 1.2 μW (cable, meas.)	1.7 μW	2 μW (DV) 4 μW (MP)	-10 % +80 %	*
JFET dissipation	7.5 mW	7 mW	7 mW	-7 %	**
RF dissipation		0	0	-	
Harness Thermal Conduction	-	-	-	-	
BDA repeatability	50(x,y)/150(z) μm on EM		125/625 μm	-	

***Verbal OK from instrument team.**

**** waived for CQM deliveries**

Note that JFET requirement has been refined

Before: **5.5 mW** (design), **11 mW** (min. performance)
7 nV/√Hz (design), **8.5 nV/√Hz** (min. performance)
design value compliant, min. performance not compliant
50 % margin held on design value (1.5*5.5 = 8.25 mW)

Now: **7 mW requirement**
90 % of channels better than **15 nV/√Hz**

Requirements Flow Back to Instrument

^{3}He fridge	290 mK delivered to BDA interface 10 μK/√Hz temperature stability < 1.0 mK/hr temperature drift at ^{3}He thermal strap
Optics	Performance defined under specified loading Filter specifications
DRCU	Detailed list of performance requirements Nominal and maximum detector signals 7 nV/√Hz total readout noise
Instrument	EMI/EMC requirement Microphonics requirement
Structure	1.7 K delivered at BDA interface Interface plate provides ± 1 mm compensation > 1 kHz resonant frequency for cables Electrically isolated 4 K RF enclosure, 40 dB attenuation

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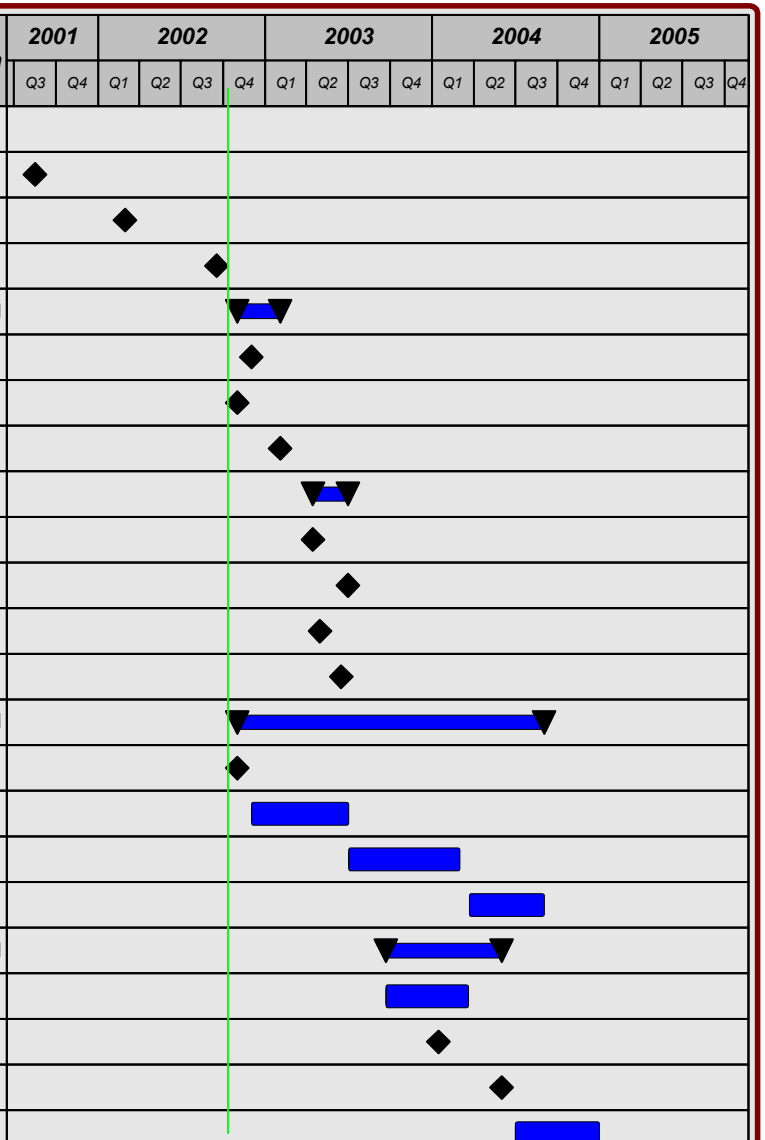
SPIRE Development Status

Development Status

SPIRE JPL Schedule Overview

ID	Task Name	Start	End	Duration
1	**PDR**	8/14/2000	8/14/2000	0w
2	**CDR**	8/16/2001	8/16/2001	0w
3	**BDA Delta Peer Review**	3/1/2002	3/1/2002	0w
4	**SPIRE Peer Review**	9/17/2002	9/17/2002	0w
5	**STM**	**11/1/2002**	**2/2/2003**	**13w 1d**
6	BDAs	12/2/2002	12/2/2002	0w
7	JFETs	11/1/2002	11/1/2002	0w
8	STM Equipment Need Date	2/3/2003	2/3/2003	0w
9	**CQM**	**4/15/2003**	**6/30/2003**	**11w**
10	PLW BDA	4/15/2003	4/15/2003	0w
11	SLW BDA	7/1/2003	7/1/2003	0w
12	SSW BDA	5/1/2003	5/1/2003	0w
13	CQM Instrument Need Date	6/16/2003	6/16/2003	0w
14	**BoDAC**	**11/1/2002**	**9/1/2004**	**95w 4d**
15	Certification	11/1/2002	11/1/2002	0w
16	CQM BDA Testing	12/2/2002	7/1/2003	30w 2d
17	PFM BDA Testing	7/2/2003	3/1/2004	34w 4d
18	FS BDA Testing	3/22/2004	9/1/2004	23w 3d
19	**PFM**	**9/22/2003**	**5/31/2004**	**36w 1d**
20	BDA's	9/22/2003	3/19/2004	26w
21	JFETs	1/15/2004	1/15/2004	0w
22	PFM Hardware Need Date	6/1/2004	6/1/2004	0w
23	**Spares**	7/1/2004	12/31/2004	26w 2d



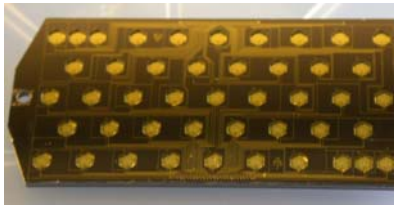
Qualification Testing Scope

- **BDAs**
  - Pathfinder Models (downgraded QMs due to engineering problems)
  - Mechanical Qual Model (MQM does not include detectors)
    - Currently in test
  - BDA Qual Model (QM does include detectors)
    - Currently in build
  - Component level qualification
    - Flex cables
    - Resistor modules
    - Kevlar cables
    - Feedhorn optical efficiency
    - Bolometers
- **RF Filters**
  - Thermal cycling
  - Cold continuity check on representative pins
  - RF attenuation measurement (Room T)
- **JFET Membranes & Modules**
  - Thermal cycling
  - Cold continuity
  - Thermal dissipation
  - Vibration

Development Status - EM & QM

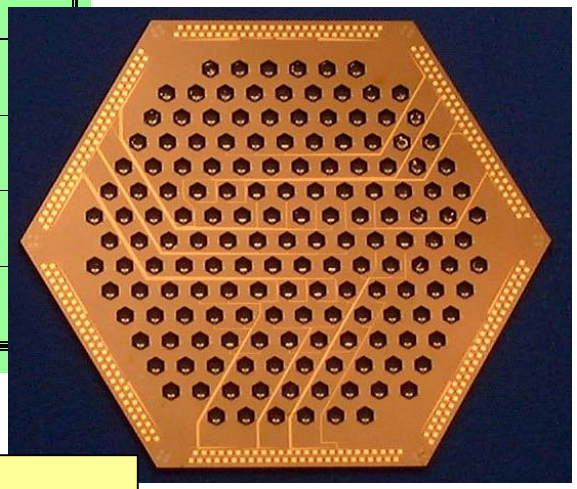
Bolometer Arrays

- **Downselect/Prototype array met performance requirements except optical efficiency**
- **Optical Efficiency**
  - **Optical efficiency of down-select unit lower than goal, but meets requirement**
  - **New tests with feedhorns + bolometers**
    - **Improved optical efficiency measured in P/SW feeds (80 +/- 10) %**
    - **S/LW feeds tested**
- **Fabrication process improvements since last annual review**
  - **Implemented Ni/In barriers to prevent In/Au reaction**
    - **Measured heat capacity of Ni and In from Planck/HFI**
    - **Completed aging tests successfully**
  - **Implemented bonding to backshort to improve mechanical strength**
  - **Refined processes to improve yield and chip bonding with excellent results**
    - **Expanded Ni contacts layer**
    - **Improved In bonding process**
    - **E-beam/stepper writes to improve lithographic yield**
    - **Improved control of etch and release process**
- **Fabricated PLW Qual and CQM arrays; SSW and SLW arrays in fabrication**



Prototype/Downselect Bolometer Array Performance

Quantity	Measured Value	Target	Units
Dark $\langle NEP_{bol} \rangle$	2.7×10^{-17}	2.5×10^{-17}	[W/√Hz]
Dark $\langle S_e \rangle$	5.88×10^{8} (± 6 %)		[V/W]
Yield	0.9	0.9	
$\langle G_0 \rangle$	54.8 ± 7.6	60	[pW/K]
$\langle C_0 \rangle$	0.96 ± 0.24	1.0	[pJ/K]
τ	11.7 ± 0.8	8 / 30	[ms]
η_{bol}	0.46 – 0.64	0.8	
1/f knee	~30	100	[mHz]
NEP_{bol}/NEP_{blip}	1.10 (+0.05, –0.15)	1.15	
DQE	0.38 - 0.53	0.60	

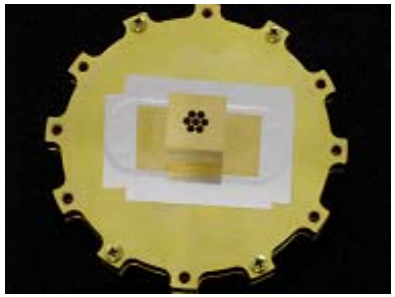


Detector performance meets design goals *except* η_{bol}
Summarized in Turner *et al.*, Applied Optics 40, 4921 (2001).

Development Status - EM & QM

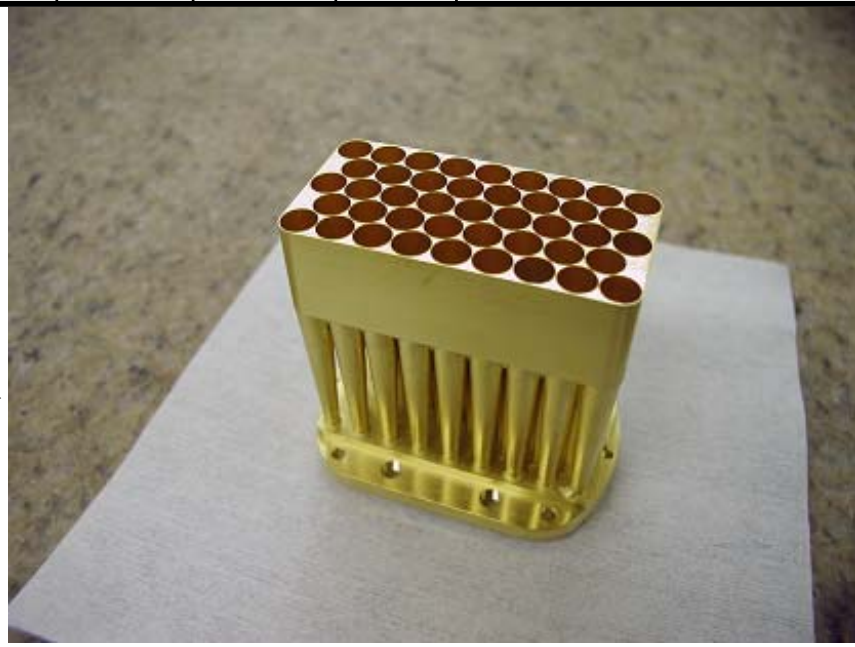
Feedhorn Performance

- **Feedhorn design and simulations completed**
  - **Prototype P/SW and S/LW feedhorns tested**
    - **P/SW most difficult to fabricate**
    - **S/LW most difficult to design**



    - **Optical efficiencies: meets design value, close to theoretical**
    - **Beams: ok, S/LW 450 μm slightly larger than calculated**
- **P/LW CQM horns have been manufactured—no show-stoppers**
  - **Implemented dimensional screening at vendor on dimensions critical to performance**

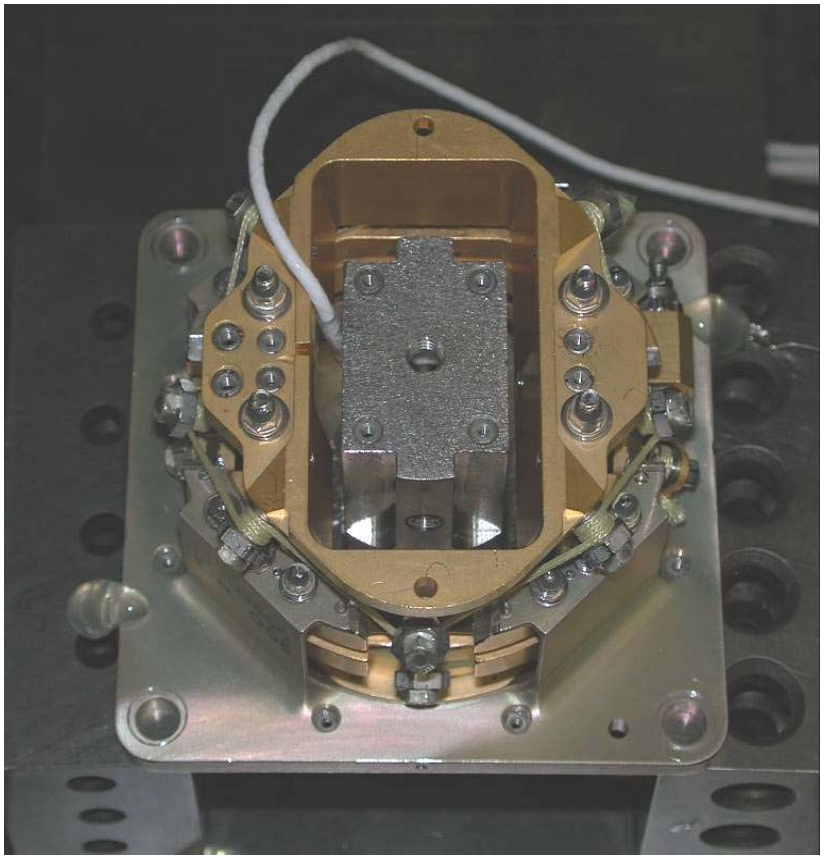
Band	ΔP Calc (pW)	ΔP Meas (pW)	η (%)	Comments
P/SW 250 μm	10.7	8.6±0.5	80±5	Cold-Calibrator efficiency 10% lower—indicative of the systematic error
S/LW 350 μm	7.2	4.9±0.2	68±3	Consistent with the HFSS predictions
S/LW 450 μm	3.8	2.1±0.2	56±5	Consistent with the HFSS predictions



Development Status - EM & QM

BDA Mechanical Qual Unit Testing

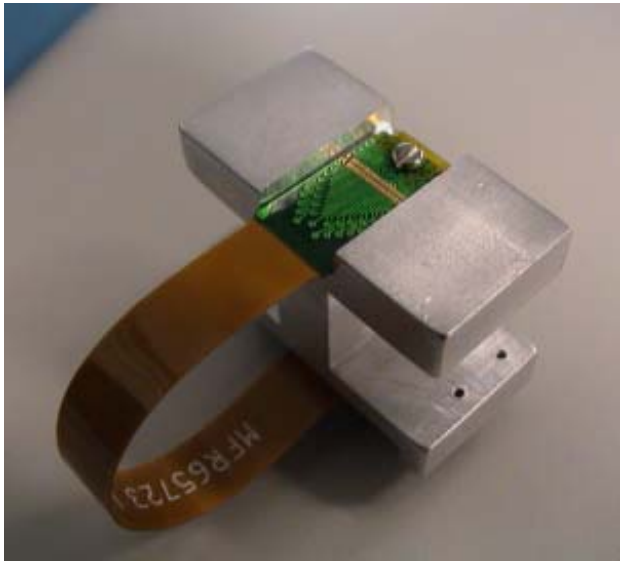
- **Pathfinder BDA (Initial MQM)**
  - Warm Vibe (3 axis) - Successful
  - Thermal Cycle - Successful
  - Cold Vibe (2 axis) - Successful
  - Cold Vibe (3rd axis) – Not successful
  - Failure analysis:
    - Aluminum flexure bent, no evident failure in kevlar suspension, 1st mode shifted out of notch
    - Smaller suspended gap than expected
    - One subassembly built to earlier revision (with snubbers)
  - Mitigation:
    - Addition of inspection step for gap
    - Corrected subassembly built and integrated
- **Mechanical Qual Model (MQM)**
  - Warm Vibe - Successful
  - Thermal Cycle - Pending
  - Cold Vibe (1 axis) – Successful
    - Modes shifted up, as expected
    - Shift in alignment of 170 microns vs. spec of 125 microns



Development Status - EM & QM

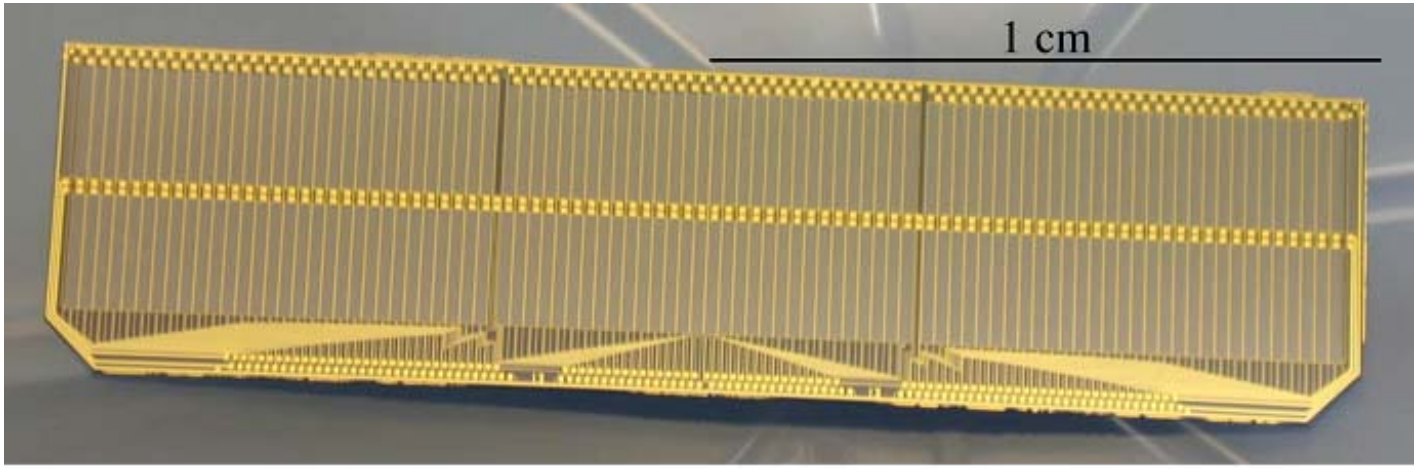
Kapton Cable

- 18 thermal cycles to 77 K
  - Outcome: Successful
    - Cold continuity check: No opens
- Accelerated aging at 85 C, 85% Humidity
  - Outcome: Successful
  - 200 Hours No Failures by Visual and X-ray Inspection
  - 200 more hours in process
- Cold vibe (suggested by Peer Review)
  - Pending
- Radius to failure (suggested by Peer Review)
  - Pending



Load Resistors Component Level Qualification

- **Load Resistor Qual Unit 1**
  - 18 thermal cycles to 77 K - No failure via cold continuity check
- **Load Resistor Qual Unit 2**
  - Performance testing at Univ. of Colorado
  - Accelerated Aging at 85 C, 85% Humidity
    - After 200 hours one out of the three LRs tested failed
    - Failure analysis: contamination problem under the metal trace
    - Mitigation: Process changed to eliminate possible contamination



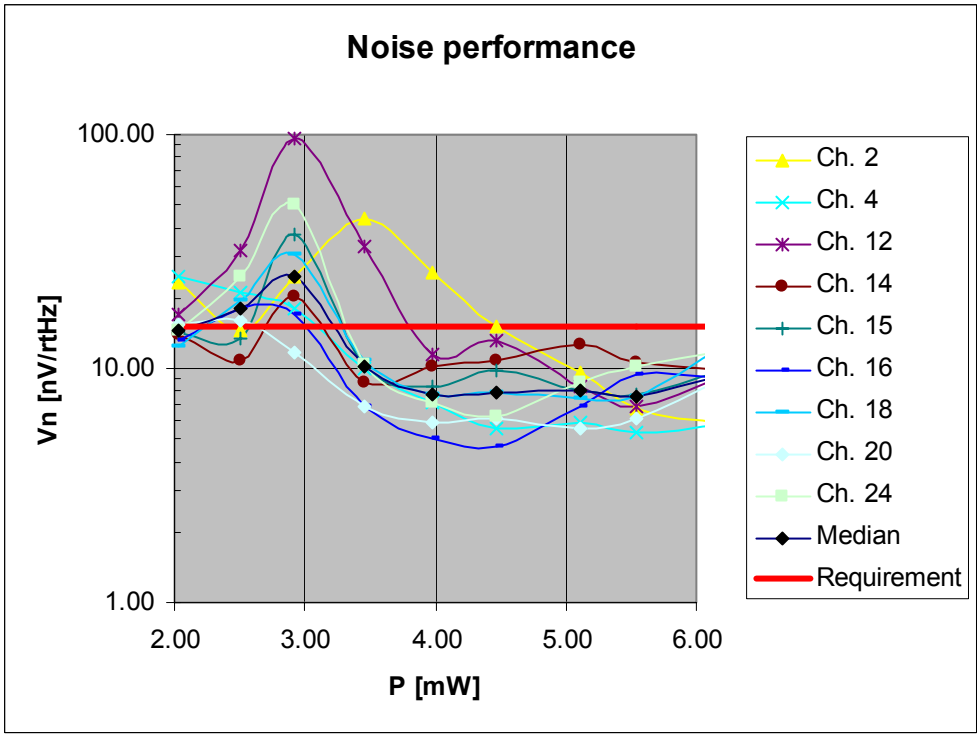
SPIRE Load Resistor (150 Meander Pairs)

RF Filters Component Level Qualification

- **RF EM Unit: Cristek MDM connector with π-filters**
  - RF attenuation testing – Successful (compares well warm to cold) (77 K)
  - 18 thermal cycles to 77 K – Successful via cold continuity check on representative pins
- **RF Qual unit delivery late from vendor due to welding issues. Will be subjected to:**
  - Thermal cycles
  - Cold continuity check on representative pins
  - RF attenuation measurement

JFET Membrane Qualification

- Yield demonstrated on EM2 and EM4 units
- Systematic study of membrane conductance
  - 1 μm membrane just at required dissipation. Complete units fabricated successfully.
  - 1 μm perforated membrane meets dissipation requirement with ample margin.
  - Verbal OK from instrument to proceed with 1 μm membranes
- Thermal dissipation/noise demonstrated on EM3 unit
  - Metal adhesion problem reduced yield
  - Process changed to fix adhesion problem and test at wafer level
- All units thermally cycled successfully
- EM unit passed vibration test
- Qualification Model unit now being fabricated



Other Areas

- **Coordination with Nasa Herschel Science Center (NHSC)**
  - NHSC code already tested and working on Planck test program
  - Excellent interaction between NASA/Herschel Science Center (NHSC) and instrument team
- **Open issue on grounding scheme and power supply selection (now resolved)**
  - Driven by cost to CEA (France)
  - Original discussions based on BOOMERANG design
  - Open issue of grounding scheme resolved satisfactorily at review held September 23-24 at RAL
- **Limited US I&T support**
  - Electronics/bolometer testing at CEA without US support
  - Increased I&T support in program during critical CQM testing

Steps to BDA Qualification

- **Fabrication completed of all QM and CQM Assemblies**
  - Intend to qualify existing design
- **Request to reduce vibration level**
  - Unit designed to survive 100 G static equivalent
  - Current qualification levels to instrument exceed flight level by 10 in G_{rms}
  - First qualify at ~45 G static equivalent and increase levels
  - Test to failure
- **Analysis of Modal Shift (upward shift expected)**
  - Tests to determine cause of downward shift
    - Drop in kevlar tension due to improper gap best hypothesis
    - Already eliminated thermal strap, belleville spring stacks as causes
  - Additional materials testing
    - CTE and cold Young's modulus of braided kevlar in use
    - Creep of braided kevlar and vespel
- **Programmatic mitigations**
  - Screening cold vibe of BDAs added to program
  - Hire additional mechanical engineer into element
  - Monthly consultation with panel of external experts
  - Parallel development of CQM and qualification units
    - No environmental testing of CQM units at JPL or RAL
    - CQM refurbishment for FSM a possible fallback to make up schedule
    - May add work in FY04

Reduction in Vibration Levels

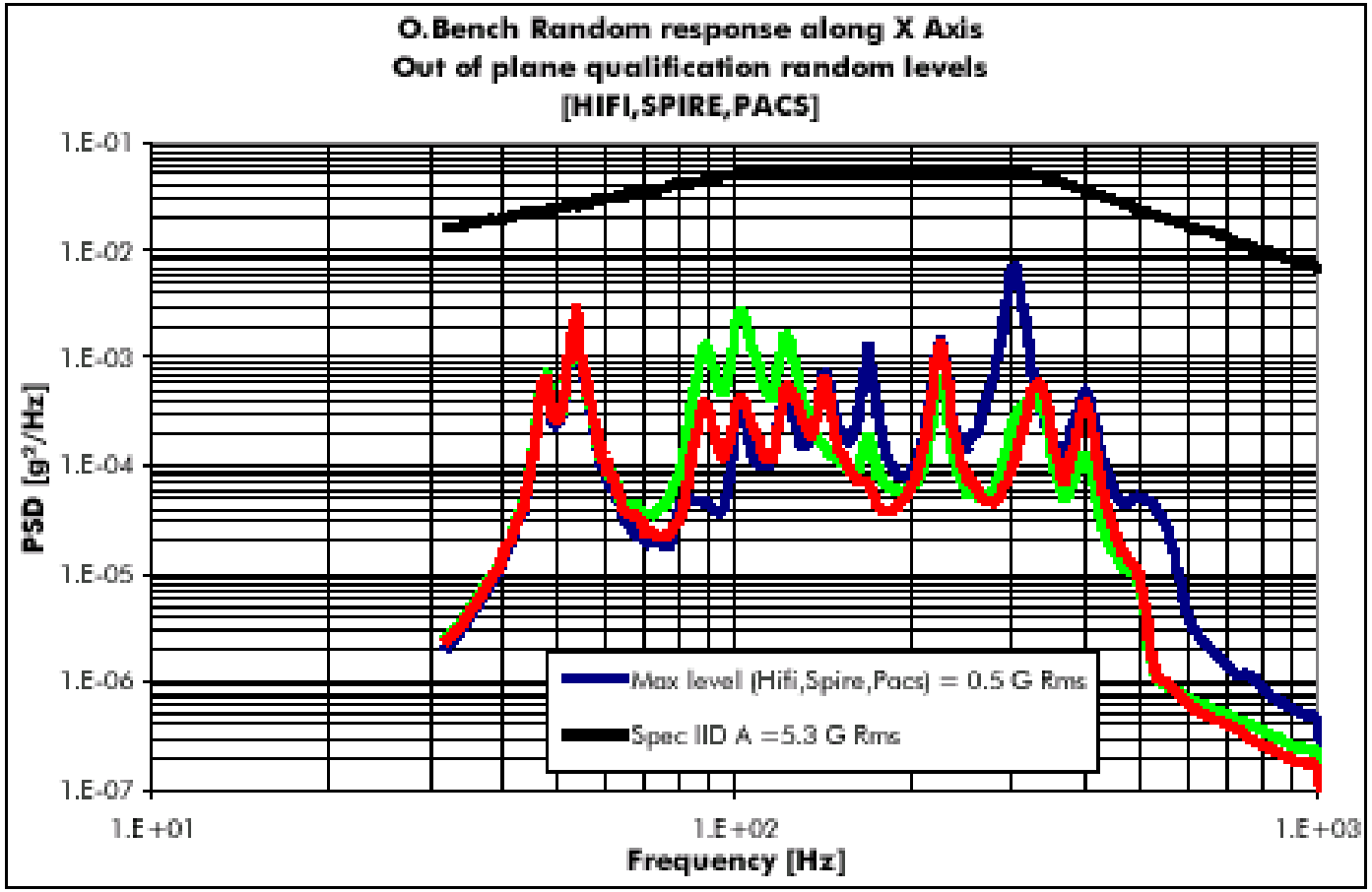


Figure 2: O.BENCH Random vibration levels along X axis (qualif levels)

Other Hardware

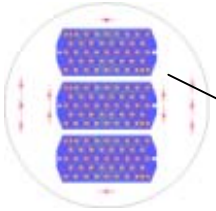
- **RF Modules**
  - Welding cracks that vendor has had difficulty in eliminating
    - Action plan: Apply JPL and local vendor experience to problem
- **JFET Membrane**
  - Thermal conduction value marginal
    - Action plan: Accept current performance pending outcome of CQM instrument testing. Mitigate with no-redesign options if still an issue.
  - Wire bonding bridges
    - Action plan: Review bonding and inspection procedures and hardware to prevent in future assemblies. Conduct pre-membrane release test inspections.
- **Kapton Cables**
  - Reliability of cable not assured with assembly and handling.
    - Action plan: Build worse case assembly ASAP, determine minimum bend radius needed, test with margin, environmentally test at earlier date, screen cables in assembly

Assessment of Design Satisfying Requirements

Compliance Matrix

Specification	Description	Demo?	Demonstration	Verification	Notes
BDA-PER-01	Detector yield	Y	Downselect array, load resistor qual unit, kapton cable qual unit	T	
BDA-PER-02	Detector sensitivity	Y	Downselect array	T	
BDA-PER-03	Photometer optical efficiency	Y	Feedhorn program	T	
BDA-PER-04	Spectrometer SW optical efficiency	N	Feedhorn program	T	LW feedhorn more difficult, tested LW instead
BDA-PER-05	Spectrometer LW optical efficiency	Y	Feedhorn program	T	
BDA-PER-06	Photometer time constant	Y	Downselect array	T	
BDA-PER-07	Spectrometer time constant	Y	Downselect array	T	
BDA-PER-08	Responsivity uniformity	Y	Downselect array	T	
BDA-PER-09	Detector cross-talk	Y	Feedhorn program	T	
BDA-PER-10	1/f knee freuquency	Y	Downselect array	T	
BDA-PER-12	Performance range in optical loading	Y	Calculation	D	
BDA-FUN-04	Positional repeatability	N	Mechanical qual unit	T	First qual unit failed req't due to bent flexure. Shifts within tolerance on earlier vibration tests.
BDA-TEC-03	BDA mass	Y	Design	T	
BDA-TEC-04	Lowest resonant mode	Y	Mechanical qual unit	T	
BDA-TEC-06	BDA conducted heat load	Y	Component test	T	
BDA-REL-01	BDA or JFET failure does not fail instrument	Y	Design, but soft failure mode requirement waived	T	
JFET-PER-01	JFET noise	Y	EM3 unit	T	
JFET-PER-02	JFET yield	Y	EM4 unit	T	
JFET-TEC-01	JFET mass	Y	Design	T	
JFET-TEC-03	RF filter attenuation	Y	Component test	T	
JFET-TEC-04	JFET lowest resonant mode	Y	Design	T	
JFET-TEC-05	JFET dissipation	N	EM3 unit	T	Within 10 % of stated requirement. Waived for CQM units.
JFET-TEC-06	RF filter mass	Y	Design	T	

BDA Assembly and Test Overview



Bolometer Wafer

LR Wafer

Backshort Wafer

Metal Parts

Bolometer Array

LR Units

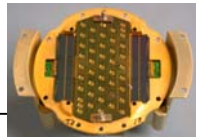
Kapton Cables

Backshorts

Feedhorns

BDA Structure

Detector Assembly



Screening

Integration

Envir. Testing

Perfor. Testing

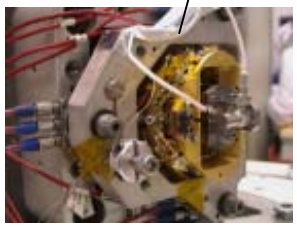
Ship

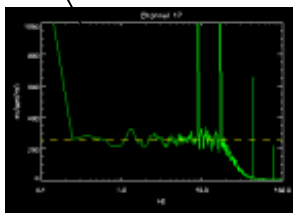
Micro-Devices Laboratory (Podosek)

Electro-Mechanical Packaging (Husted)

Environmental Testing (Sukhatme)

Performance Testing (Nguyen)





Bolometer Fabrication Status

Device	# Good Light Pixels	Total # Light Pixels	# Good Dark Pixels	# Good Thermometers	Light Pixel Yield	Device Designation	Current Status
EM 1.PSW.3	4	7			57%		At U of Colorado - Feedhorn test
EM 1.SLW.4	6	7			85%		At U of Colorado - Feedhorn test
PLW1.1	28	43	1	2	65.1%	2nd Qual P/LW	Ready to assemble to backshort
PLW1.2	39	43	2	2	90.7%	CQM P/LW	Ready to assemble to backshort
PLW1.3		43					Awaiting chip bonding
PLW2.1	38	43	1	2	88.4%	1st Qual P/LW	Delivered to EP, assembly error
PLW2.2	36	43	2	2	83.7%	BLAST	Ready to assemble to backshort
PLW2.3		43					Chip bonded and awaiting release
SLW1.1,2,3		19					Wafer Level Fabrication
SLW2.1,2,3		19					Wafer Level Fabrication
SLW3.1,2,3		19					Wafer Level Fabrication
SSW1. 1,2,3		37					Start Wafer Level Fabrication
SSW2. 1,2,3		37					Start Wafer Level Fabrication
SSW3. 1,2,3		37					Start Wafer Level Fabrication

Manufacturing Plan
Load Resistor Fabrication Status

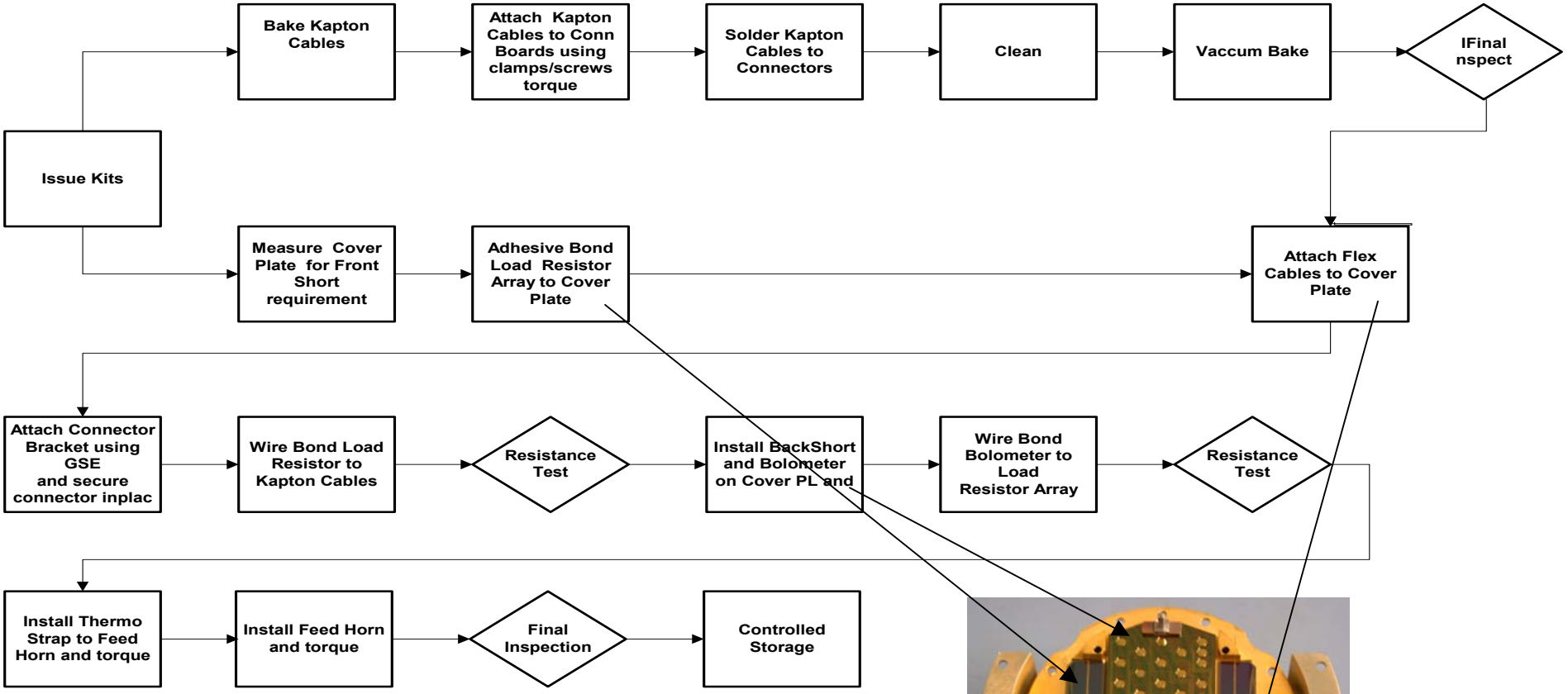
- **Micro-Devices Laboratory Ni/Cr metal deposition and E-beam lithography**
- **Automated probing significantly improved matching capability and efficiency**
  - **Complete Statistics of (30 x 3 x 2) Channels x 14 Devices = 2,520 channels**
  - **Accurately determining Good or Bad**
  - **If R pars lower than the required value, <8Mohm then tailor impedance through ion-mill**
  - **High yield achieved**

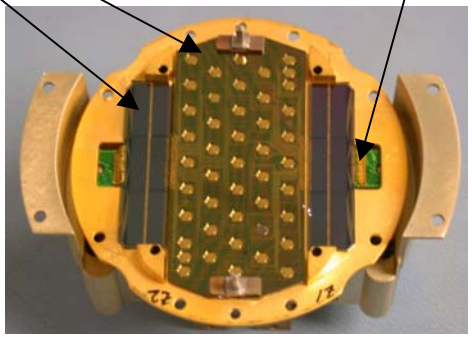
76	7.33E+06	7.53E+06	2.64	7.12E+06	7.32E+06	2.83
77	7.56E+06	7.53E+06	0.45	7.34E+06	7.32E+06	0.26
78	7.56E+06	7.53E+06	0.37	7.35E+06	7.33E+06	0.19
79	7.21E+06	7.53E+06	4.40	7.00E+06	7.33E+06	4.58
80	7.55E+06	7.53E+06	0.20	7.34E+06	7.34E+06	0.01
81	7.56E+06	7.55E+06	0.13	7.35E+06	7.35E+06	0.03
82	7.55E+06	7.55E+06	0.03	7.34E+06	7.35E+06	0.15
83	9.90E+37	7.56E+06	200.00	9.90E+37	7.36E+06	200.00
84	7.56E+06	7.57E+06	0.15	7.36E+06	7.38E+06	0.30
85	7.47E+06	7.57E+06	1.45	7.27E+06	7.38E+06	1.58
86	7.56E+06	7.58E+06	0.26	7.36E+06	7.39E+06	0.41
87	7.57E+06	7.60E+06	0.37	7.38E+06	7.41E+06	0.50
88	7.34E+06	7.60E+06	3.55	7.15E+06	7.42E+06	3.66
89	7.57E+06	7.61E+06	0.59	7.38E+06	7.43E+06	0.70
90	7.59E+06	7.64E+06	0.68	7.40E+06	7.46E+06	0.79
average	**7.49E+06**	**7.48E+06**	**2.93E+00**	**7.23E+06**	**7.24E+06**	**0.42**
Bad Cells	1	0	6.00	1	0	**6**
% Yield	98.89	100.00	93.33	98.89	100.00	93.33

Manufacturing Plan

Bolometer and Feedhorn Sub-Assembly

- **Assembly in Electronic Packaging Facility at JPL**

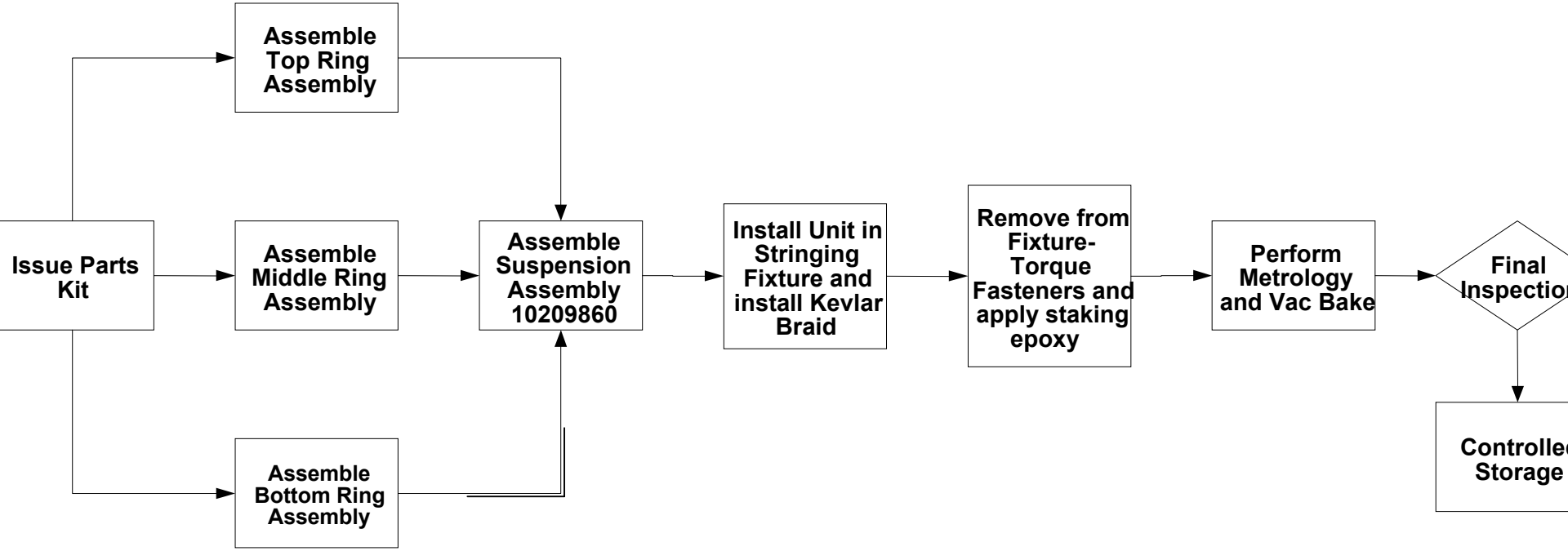




Manufacturing Plan

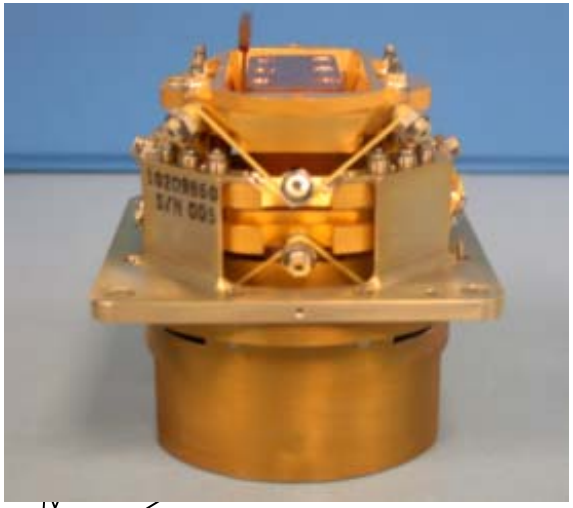
Kevlar Suspension Sub-Assembly

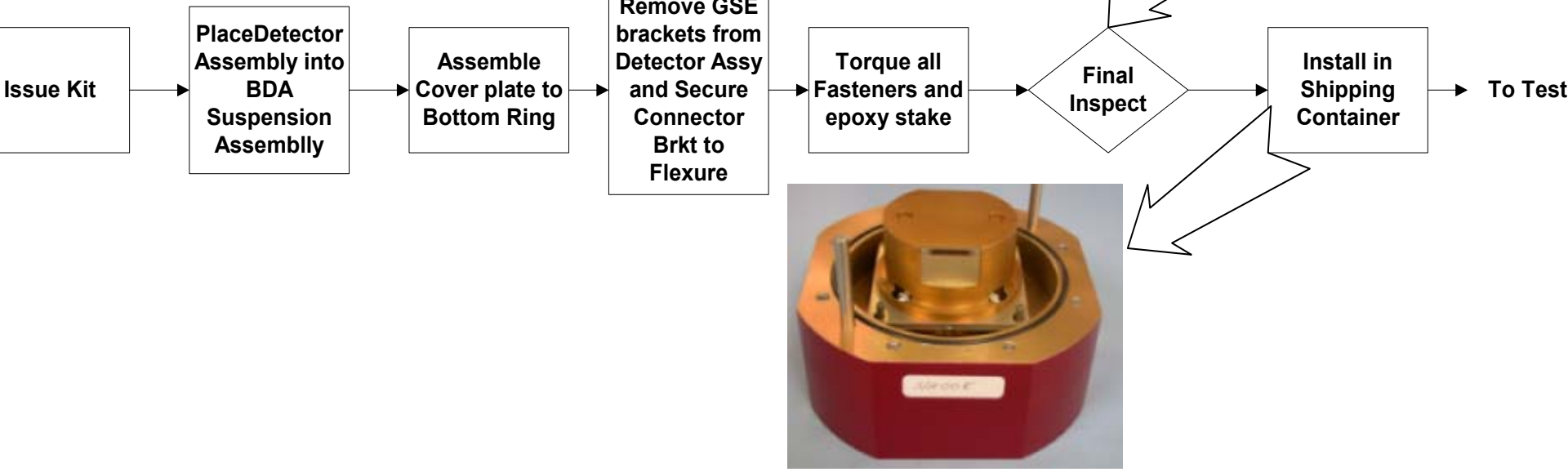
- **Assembly in Electronic Packaging Facility**



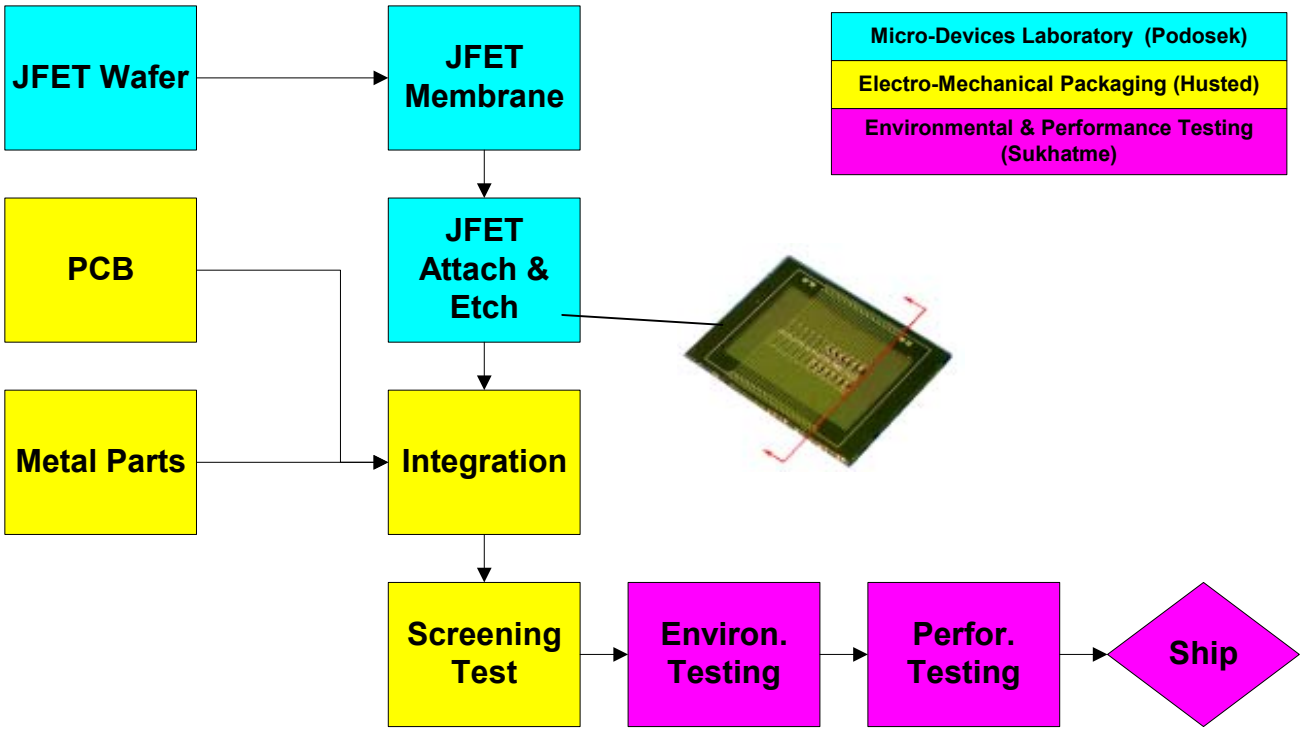
Completed BDA Assembly

- **Electronic Packaging Integrates Final BDA before delivery to Test Program Engineer**





JFET Assembly and Test Overview

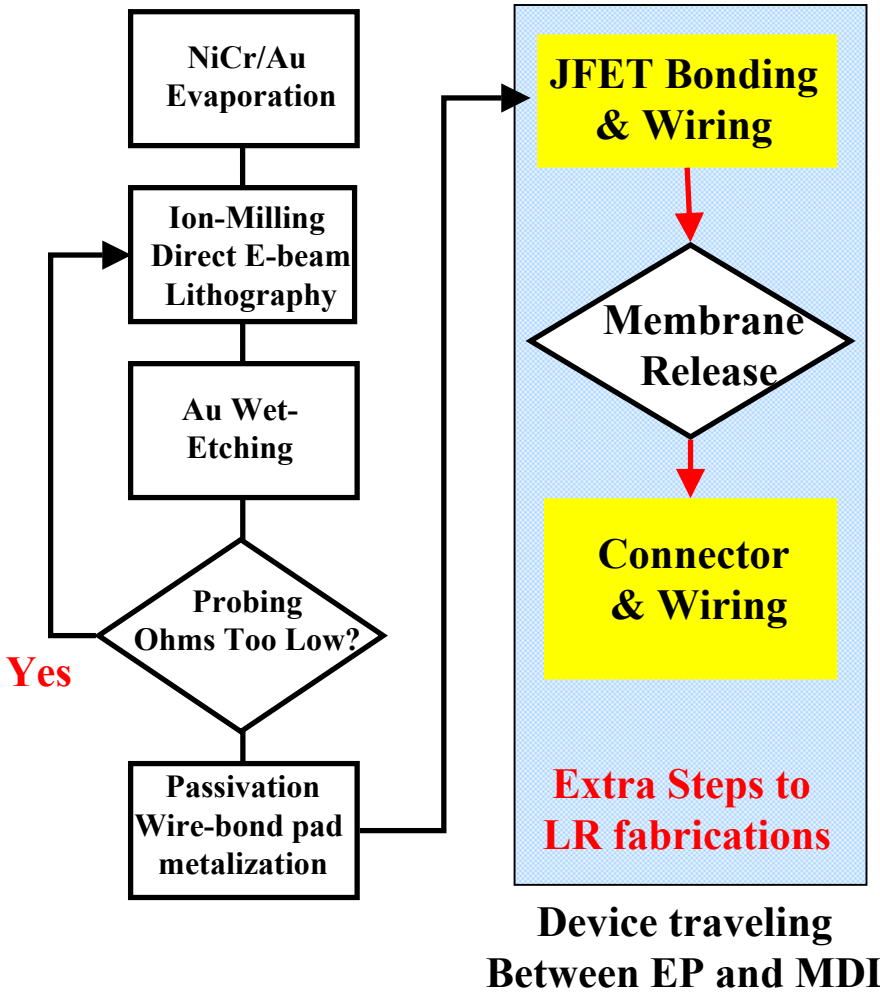


JFET Fabrication Status

- 1μm JFET 1.9.5 Successfully Released
- 1μm JFET 1.7 Wafer Ready to Go
- 1μm JFET 1.2, 1.3, and 1.4 in Queue

JFET 1.9, 1μm Nitride Membrane

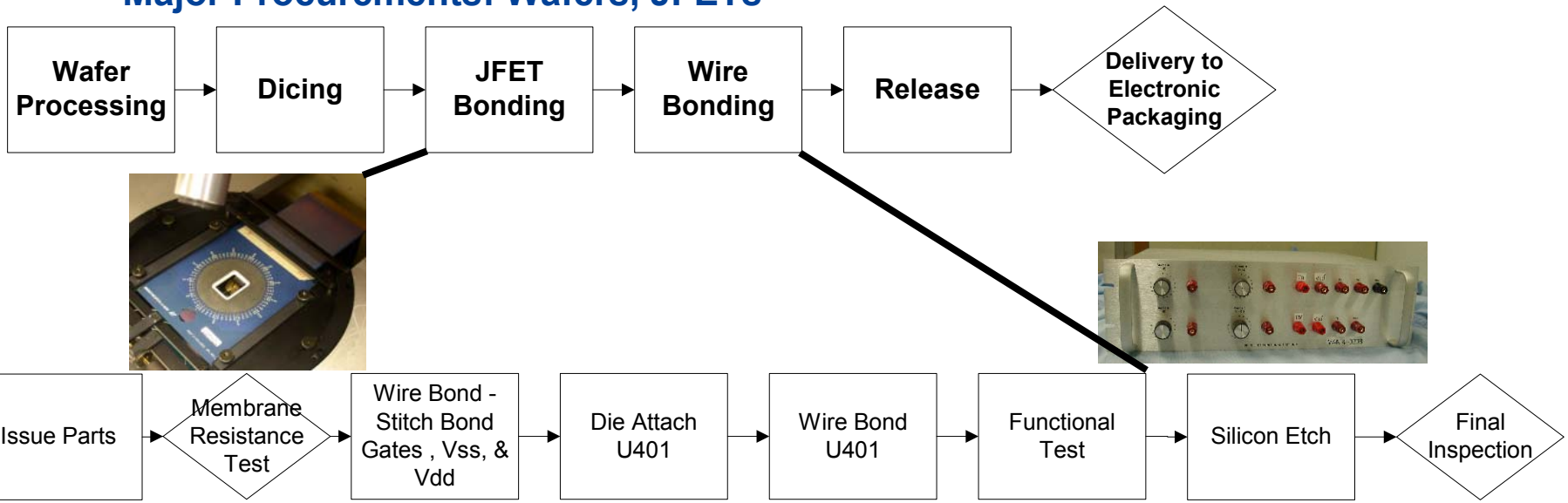
	Avg. R_s	Avg. Matching	Good/30
JFET 1.9.5	78.4	1.0%	27/30
JFET 1.9.6	77.2kohm	0.3%	30/30

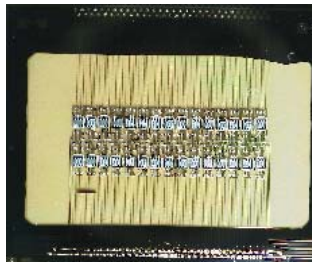


Manufacturing Plan

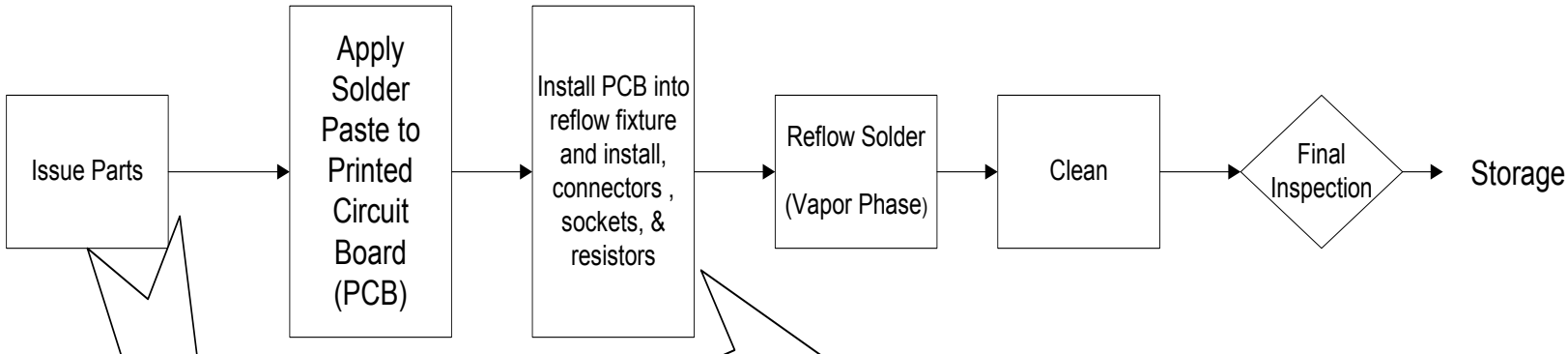
JFET Membrane Fabrication

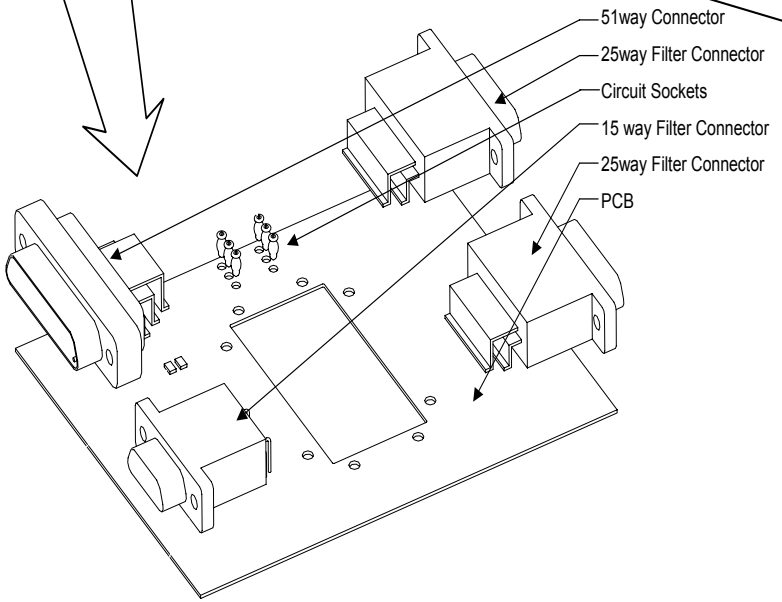
- **JFET Membranes**
  - **Facility: Micro-Devices Laboratory**
  - **Major Procurements: Wafers, JFETs**

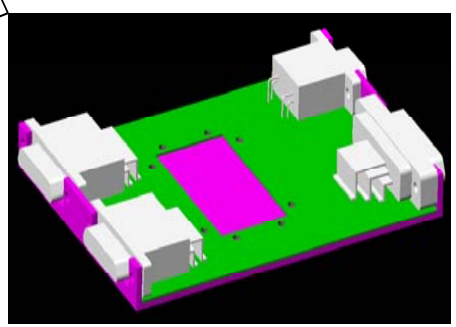




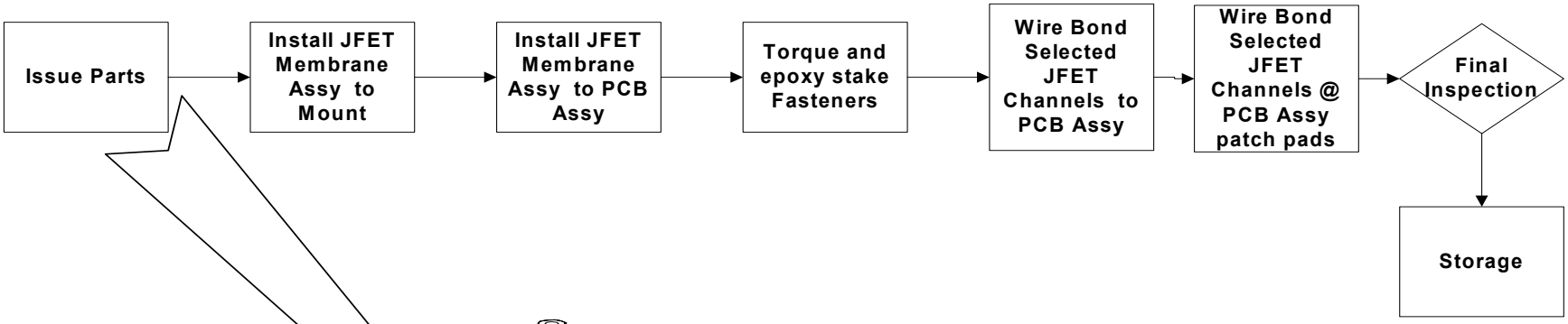
JFET PCB Integration with Connectors

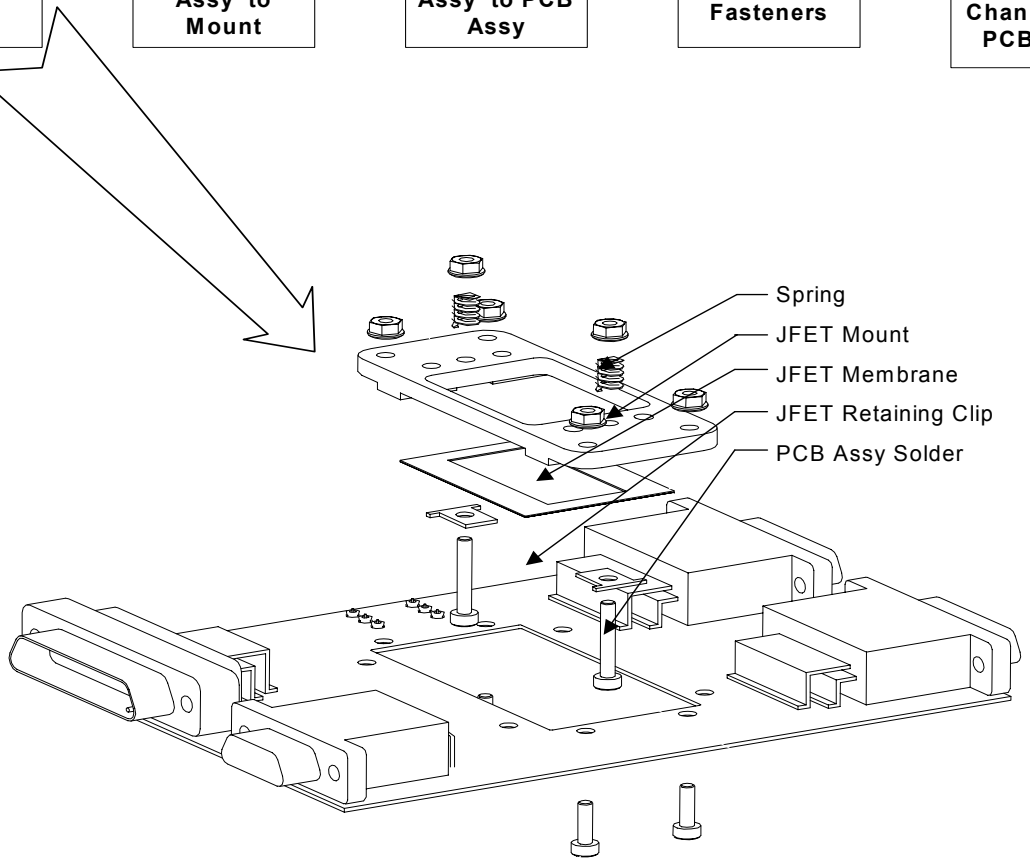






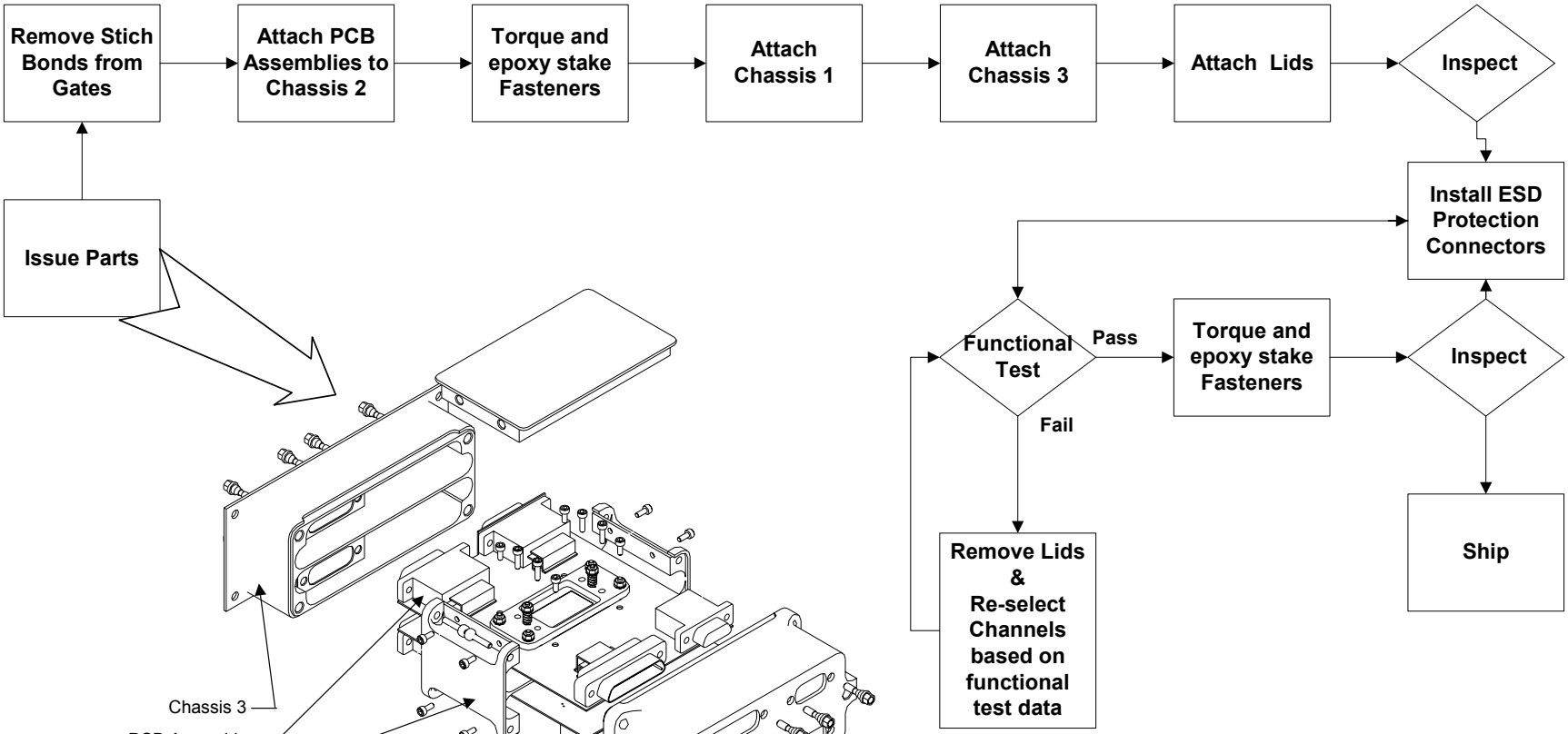
JFET Membrane Installation into Module





Manufacturing Plan

JFET Module Final Assembly



Overall Drawing Status

- All hardware manufactured to drawings under configuration control
  - In process (Assigned or in-work): 33%
  - In check: 27%
  - In approval cycle: 9%
  - Released: 31%

- Action Plans for Drawings: Push for completion and release, monthly updates of this chart at management level (Swales and JPL)

	CQM/ FLT	Non-CQM FLT	GSE	STM	ICD's	TOTAL	% of Total
Allocated	0	0	0	0	0	0	0%
Assigned	0	4	22	0	1	27	12%
In-Work	12	14	16	6	0	48	21%
In-Check	5	0	55	0	1	61	27%
Approval	15	0	0	2	3	20	9%
Released	43	0	10	15	1	69	31%
Total	75	18	103	23	6	225	100%

Documentation and Procedures Status

Agreed-To Document Status

Document	Version	Status	JPL Sign.	Europe Sign.	Comments
Business Agreement	2.0	Complete	Y	Y	Needs schedule revision
	3.0	In work			Dates under negotiation
BDA Specification Doc.	3.1	Complete	Y	Y (RAL) N (CEA)	Update will include new CMRR and vibe requirement
JPL-CEA MOU		Complete	Y	Y	
ICD Document	7	90 % done	Y	N	Materials data lacking
BDA 10209721	-A	Complete	Y	Y	
JFET 10209722	-A	Complete	Y	Y	
RF filter 10209723	-A	Complete	Y	Y	
Wiring 10209723	-A	Complete	Y	Y	
T/C 10209726	-A	Outstanding	N	N	T/C not on CQM
STM ICD		In work			Drawings not complete
JFET rack ICD		Complete	Y	Y	
Thermal strap ICD		Complete	Y	Y	
Cabling ICD		Complete	Y	Y	
Filter ICD		Complete	Y	Y	
Harness Definition Doc.	1.0	Complete	N	N	Agreed but not signed
JPL Test Plan	1.0	Complete	Y	Y	2.0 in rework
SPIRE PA Requirements		Complete	Y	Y	
Integration Procedures		Not written			

Documentation & Procedures Status

Bolometer Array and Backshort

Detector Type	Procedure Documentation	A	R	L-edit file document	A	R	Drawing Number	A	R	AIDS	A	R	S
3 PLW required PLW.2.1Photometer Long Wave Detector QUAL PLW.BS.1.1Photometer Long Wave Qual Backshort PLW.1.1Photometer Long Wave Detector QUAL Photometer Long Wave Qual Backshort PLW.2.3 Photometer Long Wave Detector CQM/FS Photometer Long Wave CQM/FS Backshort Photometer Long Wave Detector FM Phototometer Long Wave FM Backshort	EP518503 C EP518504 B EP518506 A	X X X		D23190 D23191	X X		10209811 10209812			221733 , 227038 235457 235830 N/A 235682 235517 235640 N/A	X X X X X X		X
2 SLW required SLW.1 Spectrometer Long Wave Detector SLW.2 Spectrometer Long Wave Detector SLW.3 Spectrometer Long Wave Detector Spectrometer Long Wave Backshort				D23196 D23197	X X		10209841 10209842			235744 235745 235746 N/A	X X X		
2 SSW required SSW.1 Spectrometer Short Wave Detector SSW.2 Spectrometer Short Wave Detector SSW.3 Spectrometer Short Wave Detector Spectrometer Short Wave Backshort				D23198 D23199	X X		10209851 10209852			235911 235912 235913 N/A	X X X		
2 PMW required Photometer Medium Wave Detector Photometer Medium Wave Backshort				D23192 D23193			10209821 10209822						
2 PSW required PhotometerShortWave Detector PhotometerShortWave Backshort				D23194 D23195			10209831 10209832						

Documentation & Procedures Status

JFET Membrane & Load Resistor

Document Title	Document #	Status
JFET Membrane Resistance Test Procedure	TP518890	In Approval
Load Resistor Fabrication Process	EP518549	In Approval
Load Resistor Fabrication Traveler	N/A	
JFET Membrane Fabrication Process	EP518511	In Approval
JFET Membrane Fabrication Traveler	N/A	
JFET Stress Analysis Report	D21996	In Approval
JFET Membrane Resistance Test Procedure	TP518890	In Approval
JFET Membrane L-Edit File	D23200	In Approval

Documentation & Procedures Status

BDA Assembly

Document Title	Document Number	Status		
		In work	% Complete	PDMS Release
Drawings-				
BDA Drawing	10209800		100%	10/4/2002
Detector Assembly	10209810		100%	10/4/2002
Suspension Assembly	10209860		100%	10/4/2002
Middle Ring Assembly	10209890		100%	10/4/2002
Top Ring Assembly	10209870		100%	10/4/2002
Bottom Ring Assembly	10209880		100%	10/4/2002
Machine Parts	Various		100%	10/4/2002
AIDS-				
BDA	Various	X	25%	10/15/2002
Detector Assemby	Various	X	30%	10/15/2002
Suspension Assemby	Various		100%	
Middle Ring Assemby	Various		100%	
Top Ring Assemby	Various		100%	
Bottom Ring Assemby	Various		100%	

Documentation & Procedures Status

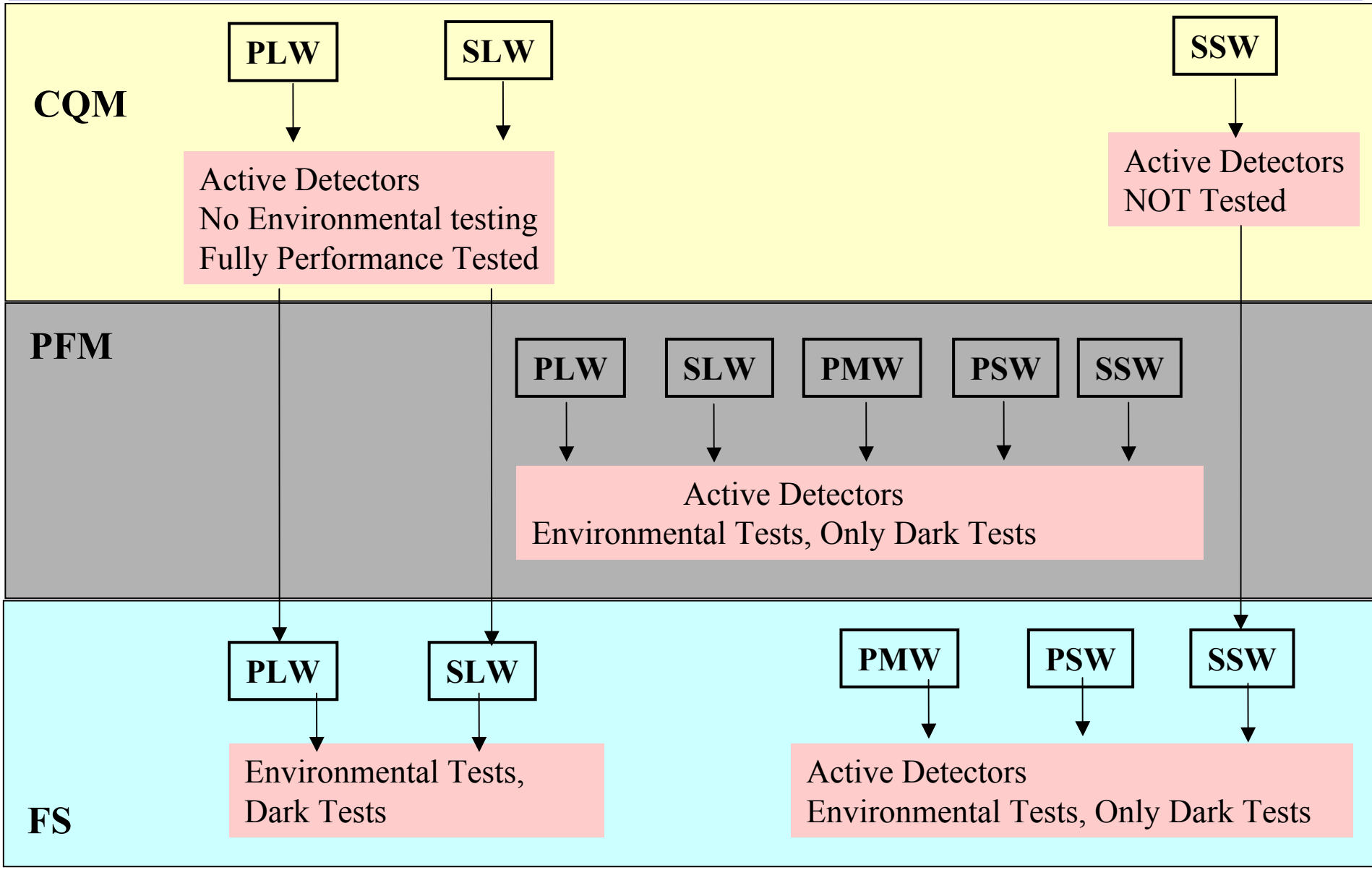
JFET Module

Document Title	Document Number	Status		
		In work	Complete	PDMS Release
Drawings				
JFET Module Assembly	10209750	x	85%	11/1/02
JFET PCB Assembly	10209760	x	85%	11/1/02
JFET PCB Assembly, Solder	10209761	x	85%	11/1/02
JFET Membrane Assembly	10209758	x	50%	11/1/02
JFET Membrane	10209758	x	25%	11/1/02
Machine Parts	Various		100%	10/15/02
AIDS-				
JFET Membrane Assembly	Various	x	95%	10/4/02
JFET PCB Assembly	Various	x	50%	10/18/02
JFET PCB, Solder Assembly	Various	x	95%	10/4/02
JFET Module Assembly	Various	x	0%	10/18/02
Test Procedures				
Resistance Test	TP518890	x	100%	10/4/02

Environmental Testing

• SPIRE Test Plan	JPL D-20549 Rev A	Released
	JPL D-20549 Rev B	In work
• AIDS		
– BDA (Vibration Tests, Thermal Cycling)		100 %
– BDA Cold Alignment Measurement		25 %
– JFET (Vibration Tests, Thermal Cycling)		25 %
– JFET (Functional Measurements)		25 %
• Vibration Test Plans		
– BDA Warm Vibration Test Plan	JPL D-22969	100 %
– BDA Cold Vibration Test Plan	JPL D-24013	100 %
– JFET Vibration Test Plan	JPL D-20550	75 %
– JFET and RFF Module Characterization Procedure		25 %

BDA Hardware Test Flow



JFET and RF Filter Module Test Plan Overview

- **Qualification Phase**
  - 1 JFET Module – T/V cycling, cold vib, noise
  - 1 RF Filter Module – T/V cycling, filter attenuation
- **CQM Phase**
  - 3 JFET Modules – T/V cycling, warm vib, noise, check & rewire, noise
  - 12 RF Filter Modules – T/V cycling, filter attenuation
- **PFM Phase**
  - 8 JFET Modules – T/V cycling, warm vib, noise
  - 12 RF Filter Modules – T/V cycling, filter attenuation
- **FS Phase**
  - 5 JFET Modules – T/V cycling, warm vib, noise

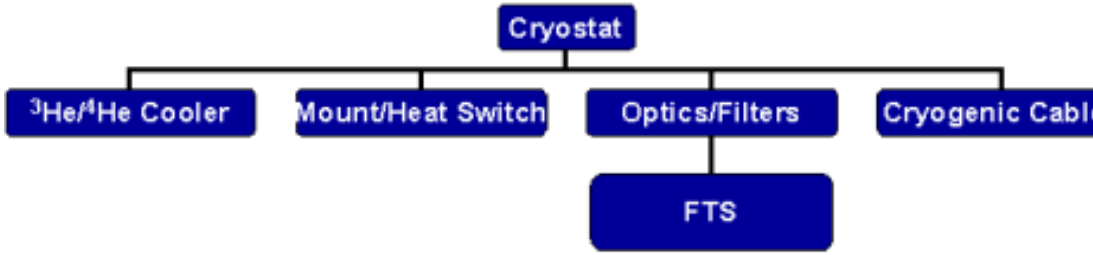
BoDAC Testbed Facility

- **Requirements**
  - Instrument to characterize SPIRE bolometers performance, for CQM, PFM and FS.
  - Clean and safe environment for flight BDA assembly
  - Cryostat and Cooler to provide 300 mK operating temperature
  - Readout Electronics, DAS and Software to be compatible with Bolocam/Planck Testbed
- **Status:**
  - Facility nearing completion
  - Test Readiness Review scheduled for October 15, 2002
  - Certification scheduled for November, 2002

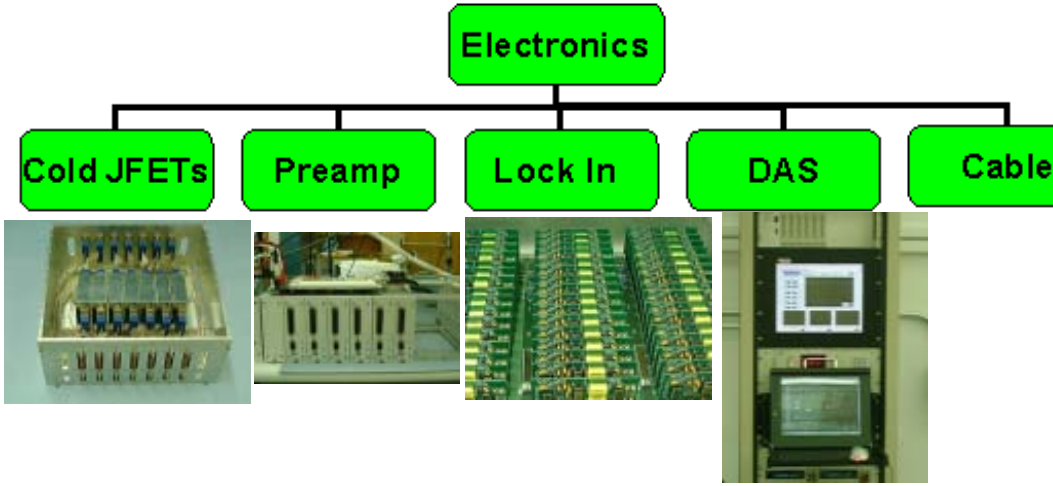
BoDAC Corner, Room 183-215

SPIRE BoDAC Facility Schematic

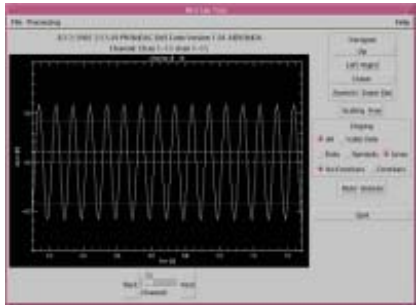
- ^{4}He Cryostat
  - Hold time > 5 days
  - No pumping, automated cycle



- Electronics
  - JFETS, Preamp, Lock-in, DAS, cable all in place



- Software
  - Developed with NHSC support
  - Based on Planck HFI except with 144 channels



SOFTWARE (NHSC)

Reliability Analysis - FMECAs

- **FMECAs**
  - **Electronic FMECA**
    - Released July 17, 2001, 5131-01-104
  - **Mechanical FMECA**
    - Released February 5th, 2002, 5131-02-010
    - Rev A released July 8th, 2002
      - Revision needed to reflect removal of snubbers from design
      - Memos documenting rationale: SPIRE 02-015 and 5131-02-187
  - **GSE BoDAC FMECA**
    - In work – To be completed October 15, 2002

Adherence to JPL standards (e.g., design principles)

- Audit completed to new revision of Principles April, 2002
  - NO NON COMPLIANCES
  - All other principles either
    - C – Compliant
    - IC – Intend to be Compliant
    - PC – Partially Compliant
      or
    - N/A – Not Applicable
- Comply with all other applicable standards
  - E.g., D-560 (Safety)

Summary of How PA/QA/CM/Safety Plans Are Implemented in Element

- **MATERIAL AND PROCESS SELECTION AND CONTROL**
  - JPL M&P experts sign off all flight drawings
- **ELECTRONIC PARTS SELECTION AND CONTROL**
  - Electronic Parts approval for small number of components in SPIRE
- **CLEANLINESS AND CONTAMINATION CONTROL**
  - Through design (materials & processes qualification) and handling processes(facilities (assembly, integration and test (including clean rooms and ground support equipment), test area facilities, transportation and storage) and operational procedures).
- **RELIABILITY ASSURANCE**
  - FMECA, WCA, PSA conducted by reliability. Environmental Testing at Subsystem Level
- **SAFETY ASSURANCE**
  - Principally through compliance with JPL D-560 (JPL Standard for Systems Safety), JPL Spec. ES501492 (Safety Requirements for Mechanical Support Equipment for JPL Critical Items, Equipment Specification for) and MIL-STD-1522 Aerospace Pressure Vessels Standard.
- **QUALITY ASSURANCE**
  - Key processes throughout lifecycle: Training and Certification, Contractor Surveillance, Raw Material Controls, Receiving Inspection, Processing, Fabricating, Assembly, Test, and Inspection Control, Manufacturing, Inspection and Test Planning, Inspection Critical Processes, Workmanship Standards, Metrology Controls, Controlled Storage, Handling, Packaging, Shipping and Storage Controls, Record Maintenance, Acceptance Test Verification, Preparation of Test Procedures/Specifications, Environmental Testing, Functional and Acceptance Electrical Testing, Post-Test Hardware Inspection, Ground Support Equipment, End Item Data Package (EIDP), Hardware Requirements/Certification Reviews (HRCRs),.
- **SOFTWARE PRODUCT ASSURANCE**
  - For JPL efforts, applicable to GSE only
- **CONFIGURATION MANAGEMENT AND CONTROL**
  - All documents under CM released through PDMS.

IR and PFR status

- Weekly meetings to be held to create and monitor action plans to close IRs and PFRs
- One Developmental PFRs open against flexure failure of BDA
  - Disposition of PFR to be made once evaluation is completed
- Inspection Reports (IR)'s
  - Total: 220
    - Closed: 42
    - Open: 178
      - Cognizant Engineer Disposition: 33 – waiting for Cog-E to disposition items
      - QAE Concurrence: 2 – waiting for QAE to concur
      - Init: 2 – Initiated
      - Pending Action: 141 – pending some action (rework, retest, drawing release, etc.)

Peer Reviews

- BDA Tiger Team formed after CDR, Fall of 2001
- BDA Peer Review held in February 2002
  - Objective: To review changes implemented since project CDR
  - 22 AI's generated
    - 16 closed, 6 in continued resolution
- Annual Peer Review held 17 September 2002
  - Received 20 Request for Action
    - 19 accepted, 1 advisory
    - 7 completed to date
  - Received Additional Issues for Concern from Preliminary Report
    - Technical concerns reflected in requests for actions
    - Management concerns reflected in project presentation
  - Awaiting Formal Report

2002 Peer Review

Request for Action Summary (1)

#	Statement of Concern	Recommended Action	Disp.	Responsible Individual	Status	Comments
1	Actual power dissipation of BDA is not measured directly	Test	Accepted	H. Nguyen	Done	Experimental accuracy uncertain
2	Flexure failure needs analysis	Test	Accepted	L. Husted	In work	Awaits disassembly of unit
3	Change in tension over time	None requested	Accepted	K. Sukhatme	In work	Need to devise test
4	Kapton cable breakage in handling a concern	Radius to failure, cold vibe	Accepted	K. Sukhatme	In work	
5	Need analysis for open circuits in QM assembly	Inspect	Accepted	L. Husted	In work	
6	Grounding scheme disagreement	Implement cold end grounding based on Boomerang	Accepted	J. Bock	Done	Resolved at grounding review at RAL
7	Coupled stiffness in suspension system drops modal frequency	Test with shims	Accepted	L. Husted	Done	Modal frequencies now shifting up, as expected.
8	Descope JPL optical testing	Install cold calibrator lamp	Accepted	H. Nguyen	Done	Optical tests on CQM can be eliminated if required by schedule
9	End-to-end yield of BDA needs a distributed budget	Construct budget based on yield data to date	Accepted	J. Bock	In work	Need improved data set
10	Demonstration of BDA mechanical reliability	Cold vibe screening	Accepted	K. Sukhatme	Done	Now implemented in plan for one-axis test.
11	Schedule	Resolve current delivery dates with instrument	Accepted	G. Lilienthal	In work	Current CQM and PFM dates have verbal OK
12	Schedule	QA oversight during testing and shipping needs to be expedited	Accepted	G. Lilienthal	In work	
13	FEM analysis does not predict behavior	Eliminate modal analysis	Accepted	L. Husted	Done	
14	Determine maximum vibration level BDA can tolerate	Shake to failure cold	Accepted	K. Sukhatme	In work	

Source: Peer Review Chairman's (P. Richards) preliminary report

Request for Action Summary (2)

#	Statement of Concern	Recommended Action	Disp.	Responsible Individual	Status	Comments
15	Are not converging to a workable design	Convene an ongoing (mini) tiger team with some experts like Bob Bamford and others to help the SPIRE team along to finish the task.	Accepted	G. Lilienthal	In work	Propose monthly meetings with gurus starting October. In addition, add an experience Div 35 engineer to staff. Address management problems.
16	The time has come to build and test the BDA to a reasonable vibration test level.	Urge the Europeans to quickly settle the issue of vibration levels.	Accepted	G. Lilienthal	In work	Agreed on approach. ESA requires test data from instrument team to reduce levels.
17	Strength of flexure	Remake the flexures with invar to positively prevent bending.	Advisory	Husted/Crumb		May isolate kevlar modes. STM hardware will isolate flexure modes (this is free). Possibly could also buttress the flexure in the existing assembly.
18	There is no test currently planned to ensure that there is no contact between the suspended structure and the surrounding structure of the BDA.	Design a test to confirm that there is no touching of the suspended structure in the BDA.	Accepted	H. Nguyen	Done	Thermal cycle facility to implement electrical continuity test. Thermal conductance to be measured in BoDAC. Eliminated snubbers from design.
19	How fast is the simulator lamp?	Check with Jeff Beeman for the spec on his lamp.	Advisory	Nguyen	In work	
20	Comment from Paul that he doesn't think the benefit of the perforated membranes is high at this time.	Eliminate plan to develop perforated membranes.	Accepted	J. Bock	In work	Reworking JFET dissipation requirement with instrument team based on refined thermal analysis of instrument with industrial partner in Europe
21	Analysis needed of effects of JFET noise margin, refrigerator margin, heat strap, conductance, etc. on the the pixel sensitivity.	Complete a pixel sensitivity analysis.	Accepted	J. Bock	In work	A worse case analysis has already been completed prior to the review by M. Griffin et. Al. A more detailed analysis has been started.

Top 5 Technical Risks and Mitigations

Priority	Risk	Prob-ability	Impact	Mitigations
1	BDA structure qualification	5	10	Measure material properties warm and cold
				Cold vibe screening
				Qual for aging and fatigue
				Add mechanical engineer
				Consulation with Mini-Tiger Team experts
				Lower vibe level
				Deliver CQM units without environmental testing
2	BoDAC certification late	7	8	Pathfinder testing
				Cable characterization
				JFET ESD protection connectors
				UC qual performance testing
3	JFET qualification	5	9	Deliver CQM units without envirnomental testing
4	Detector cracking	3	7	Test smallest gap in qual model
5	Kapton cable qualification	5	3	Cold vibe
				Radius to failure
				Buy spares or thicker constantin
				Go/nogo screening in assembly
				Test in qualification

Risks (2)

Priority	Risk	Prob-ability	Impact	Mitigations
6	JFET noise / dissipation	6	8	Refine requirement with instrument team
				Worst-case analysis
				CQM statistics
				Study perforated membrane
7	Detector hits feedhorn	3	9	Go/nogo screening in assembly
				Test in qualification
8	Rework CQM BDAs	8	6	Descope FS testing
9	BDA assembly variability	4	8	Tolerance stackup of critical dimensions
				Inspection checklist
				Cold vibe screening
10	Detector yield low	8	4	Refine etch process
				Add Jerry Mulder to team
				Formulate yield budget
11	LR aging	7	5	Wafer-level screening
				Investigate alternate test
12	JFET yield	5	5	Complete AIDS
				Go/nogo screening in assembly
13	Load resistor through connects	8	3	Probe card screening
14	BDA touch / dissipation	3	8	Continuity test in TC dewar
				Conductance test in BoDAC

Risks (3)

Priority	Risk	Prob-ability	Impact	Mitigations
15	Feedhorn performance	8	3	List of critical dimensions for CM
16	JFET aging	5	8	Implement abbreviated screening test
17	Bolometer performance	4	9	Worst-case analysis
18	BDA alignment	5	3	Cold vibe screening
19	Temperature control implementation	3	5	Test in CQM instrument
20	Backshort accuracy	8	3	Stackup analysis
				Lap and polish wafers
21	Opens or shorts during test	8	3	Cold continuity testing
				Tracking sheets
22	JFET ESD	2	7	Protection connectors for test
23	FEM model not useful	7	5	Terminate modal analysis
24	Internal thermal conductance of BDA	5	7	Test in BoDAC

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SPIRE Programmatics

Budget

WBS Element	Work Agreement Title	Feb. '02 Budget					Lien Request Delta			
		2002	2003	2004	2005	Totals	2003	2004	2005	Totals
C.5.1.1	PEM	560	280	300	150	1,290	0	0	0	0
C.5.3.1	Co-I	204	305	387	0	896	0	0	0	0
C.5.1.2	I&T (European I&T)	0	0	0	0	0	150	150	150	450
C.5.6.2	Bolometer Fabrication	608	838	0	0	1,446	-85	80	0	-5
C.5.6.1	JFET Fabrication	326	285	0	0	611	20	0	0	20
C.5.5.1	Electro/Mechanical Systems	1,263	1,030	0	0	2,293	95	250	50	395
C.5.4.1	Test Program	735	778	709	0	2,222	130	200	0	330
C.5.4.2	BoDAC	655	450	451	0	1,556	150	0	0	150
C.5.2.1	Mission Assurance	31	38	22	0	91	0	0	0	0
C.5.2.3	Quality Assurance	223	458	17	0	698	0	0	0	0
C.5.2.4	Reliability	82	70	45	0	197	0	0	0	0
C.5.2.7	HSO Configuration Management	34	0	0	0	34	0	0	0	0
	Totals:	4,721	4,532	1,931	150	11,334	460	680	200	1,340

- Reserve held at the Project Level
- De-scope options under review to minimize the lien posture
- Six weeks of costed schedule reserve in planned budget

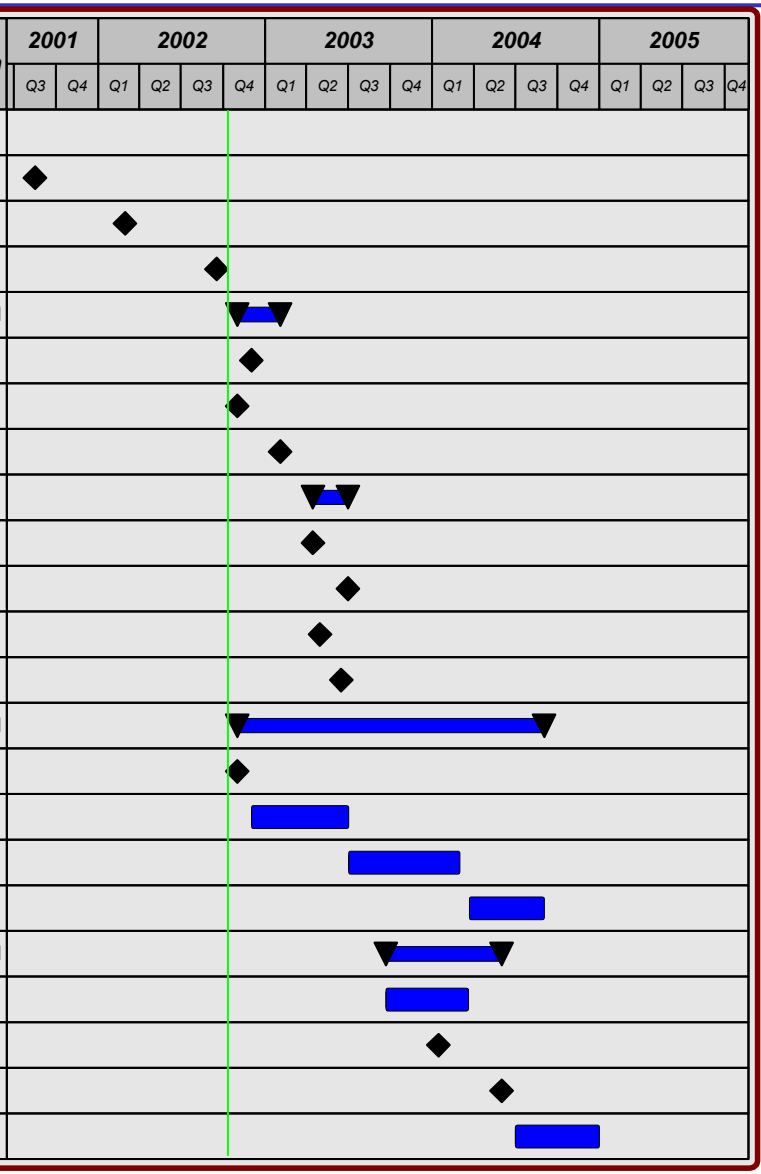
Schedule Summary

- Detailed schedule developed at grass roots level and maintained on a weekly basis
- SPIRE schedule slips have eroded margin established at beginning of C/D to point of 6 week slack in CQM delivery after newly negotiated delivery
  - Some additional slack is in the test program and identified as contingency (but will likely be needed in test program)
- Critical path up to now has been BDA mechanical qualification
  - New critical path likely to become performance testing (BoDAC)
- Hardware schedule changes negotiated with RAL
  - ECR against the Business Agreement in process to formalize deliver dates
    - Deliver last CQM BDA's in July, '03
    - Deliver STM hardware in February, '03
    - Deliver PFM hardware in March, '04

Programmatics

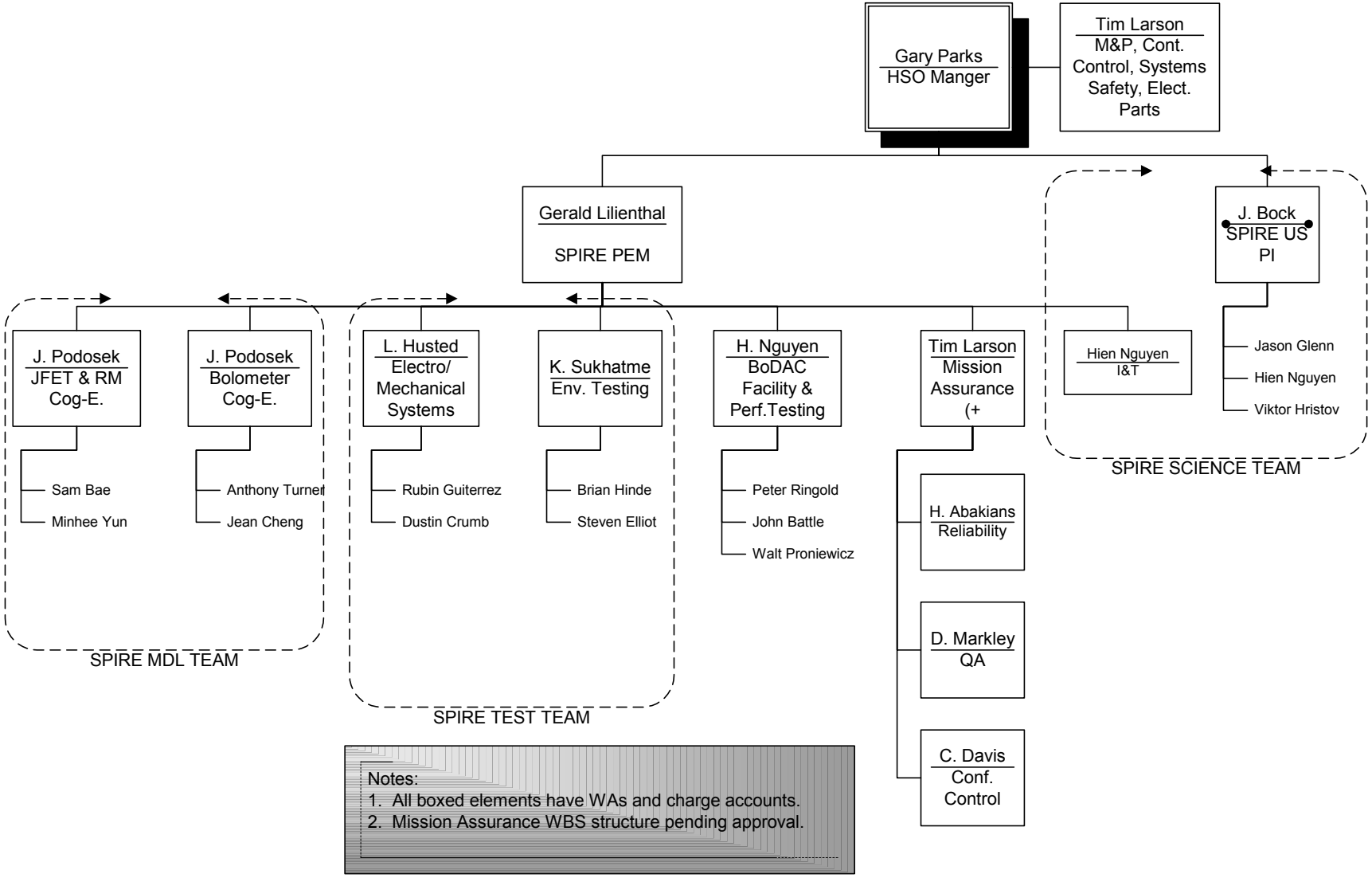
SPIRE JPL Schedule Overview

ID	Task Name	Start	End	Duration
1	**PDR**	8/14/2000	8/14/2000	0w
2	**CDR**	8/16/2001	8/16/2001	0w
3	**BDA Delta Peer Review**	3/1/2002	3/1/2002	0w
4	**SPIRE Peer Review**	9/17/2002	9/17/2002	0w
5	**STM**	**11/1/2002**	**2/2/2003**	**13w 1d**
6	BDAs	12/2/2002	12/2/2002	0w
7	JFETs	11/1/2002	11/1/2002	0w
8	STM Equipment Need Date	2/3/2003	2/3/2003	0w
9	**CQM**	**4/15/2003**	**6/30/2003**	**11w**
10	PLW BDA	4/15/2003	4/15/2003	0w
11	SLW BDA	7/1/2003	7/1/2003	0w
12	SSW BDA	5/1/2003	5/1/2003	0w
13	CQM Instrument Need Date	6/16/2003	6/16/2003	0w
14	**BoDAC**	**11/1/2002**	**9/1/2004**	**95w 4d**
15	Certification	11/1/2002	11/1/2002	0w
16	CQM BDA Testing	12/2/2002	7/1/2003	30w 2d
17	PFM BDA Testing	7/2/2003	3/1/2004	34w 4d
18	FS BDA Testing	3/22/2004	9/1/2004	23w 3d
19	**PFM**	**9/22/2003**	**5/31/2004**	**36w 1d**
20	BDA's	9/22/2003	3/19/2004	26w
21	JFETs	1/15/2004	1/15/2004	0w
22	PFM Hardware Need Date	6/1/2004	6/1/2004	0w
23	**Spares**	7/1/2004	12/31/2004	26w 2d



Programmatics

WBS/Organization



Known Programmatic Risks

- Qualification program is not completed in time for flight build
  - Complete the component level qual program
  - Rework CQM hardware if required by qual program
- CQM deliveries are late
  - Build CQM hardware in parallel with qual testing
  - Eliminate CQM environmental testing
  - Eliminate CQM optical testing if necessary
- CQM BDA rework cost in ’04
- PFM deliveries are late
  - Descope performance testing (risky)
- FY ‘04 budget
  - Prioritize flight deliveries over flight spare deliveries
    - Descope FSM testing
    - Descope PFM performance testing
    - Descope FSM program (violates agreement and ESA requirement)
- JFET additional testing or Fabrication R&D to meet stated requirement
  - Work on dissipation requirement with instrument team
    - Verbal OK that current requirement can be mitigated at instrument level
- Assembly variability of mechanical structure
  - Additional cold vibration testing
- Failure of BoDAC
  - Spare parts for all critical hardware in hand

Top Open Issues Requiring Resolution

- Update delivery dates in Business Agreement
- Resolve vibration level requirement
- Resolve JFET dissipation requirement
- BDA qualification
  - Vibration specification
  - Modal shifts
- Drawing release

Answers to review board questions (self assessment)

Previously identified concerns and deficiencies have been adequately considered and resolved	Yes (but anticipating further actions from recent peer review)
Detailed requirements and interfaces are complete and stable for next stage of implementation (post CDR manufacturing stage for most elements)	Yes (with exceptions noted)
Management and technical Implementation plans are reasonable and justifiable for the current phase of the project	Shortcomings identified and being corrected
Plans for resolving open items/problems are adequate and within available resources	In Work
Detailed designs and manufacturing plans are sufficiently defined for next phase of implementation (post CDR manufacturing stage or most elements)	Staged drawing release needed
Risk is adequately understood and controlled	Yes
Plans for Herschel and Planck Science activities will support full readiness at launch	Phase E involvement anticipated
Project lifecycle cost estimates are adequate with an acceptable level of risk	Yes, working on plan improvments

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SPIRE Appendix

Action Item Summary (1)

#	Statement of Concern	Recommended Action	Disp.	Responsible Individual	Status	Comments
1	Thermal strap mass not included in test setup.	Include mass	Accepted	K. Sukhatme	Done	
2	Ribbon cables and Nanonics connectors currently planned for SPIRE are the subject of poor performance and review on SIRTF.	It is recommended that the SPIRE PEM take action to mitigate the failings of these cables and connectors. Specifically there are issues of the electrical attachment of the connectors to the ribbon cables and also poorer than expected thermal performance.	Accepted	Tim Larson	Done 3/25/2002	Looked at the SIRTF and adopted the applicable lessons learned.
3	The alignment of the BDA needs to be verified after testing the tension of the Kevlar straps.	Verify alignment	Already Done	K. Sukhatme	Done	There is no tension testing with kevlar no
4	Measurement of the BDA position relative to the structure is not specified in the requirements.	Specify position in document.	Already Done	J. Bock	Done	Spec has requirement.
5	Currently there is not analysis of the sensitivity of the system to distribution of tension in the Kevlar braid.	A sensitivity analysis should be performed and success criteria should be developed for initial assembly and following vibration test(s).	Accepted	K. Browning	Done	Accomplished and we raised the tension accommodate expected variation.

Action Item Summary (2)

#	Statement of Concern	Recommended Action	Disp.	Responsible Individual	Status	Comments
6	Concern that we do not adequately calibrate the absolute measurement of the tensionometer	Perform an absolute calibration on the tensionometer	Accepted	L. Husted	Have eliminated tension testing.	We have calibrated the unit. However, the is an issue with the repeatibility on the BD itself. It is difficult to place the device at t same place on the segment each time an the measurement is sensitive to this parameter.
7	1. The minimum value of tension of the Kevlar braid presented (22lbs.) is based entirely support of the Kevlar and assumes perfect friction at the capstans.	Since friction is a function of the load on the Kevlar, the analysis should be done to include the effect of the reduced friction at the capstans, which will likely increase the minimum acceptable value.	Accepted	K. Browning	Done	Accomplished and we raised the tension t accommodate expected variation. We ha also designed the unit to account for measured coefficient of dynamic friction.
8	Concern that the material used for the tapered jam washer will gall and prevent disassembly.	1. The tapered jam washer should be fabricated from Nitronic 60 to avoid galling and facilitate disassembly in the event of a post-vibration failure (or readjustment).	Accepted	L. Husted	Done	Confirmed that existing parts do not have this problem.
9	Concern that the kelvar cable will not "settle-in" prior to environmental testing.	A “settling” (low-level) vibration test should be included as part of the assembly process.	Advisory	L. Husted	Done	Evaluated and not found to be practical in the EP. We do not see motion in the qua units and delivered units will be vibed befo measuring final position.
10	Concern that friction will prevent proper athermalization of the structure during cooldown.	Measure the force-displacement relationship of the Bellville stacks used in the assembly.	Accepted	L. Husted	Done	Did tests, looked at numbers. Will do col vib on qual unit and take the device throug metrology afteward.

Action Item Summary (3)

#	Statement of Concern	Recommended Action	Disp.	Responsible Individual	Status	Comments
11	The current design requires Kevlar-on-Kevlar at the capstans. This situation can result in stress concentrations in the Kevlar and result in failure.	Alter the design so that the Kevlar-on-Kevlar situation is avoided. A single wrap of Kevlar at higher forces or a larger capstan could achieve this	Accepted	D. Crumb	Done	Redesigned and tested ultimate strength or the test fixture.
12	There is insufficient data on the Kevlar braid being used.	Perform tests the better simulate how the actual system is implemented. Avoid abrasion in the additional tests.	Accepted	L. Husted	Done	Have measured data.
13	Concern that there is insufficient information to precisely determine margins.	Consider doing a “vib to failure” test of a BDA structure.	Accepted	K. Sukhatme	11/15/2002	
14	Concern that the friction coefficient needed has no tolerance.	Utilize a “knockdown factor” of 1.25 for the coefficient of friction of Kevlar on stainless.	Accepted	D. Crumb	Done	
15	Not enough information exists on the fatigue life of kevlar.	Perform one of the following: a. An analysis of fatigue life on the Kevlar braid, b. Perform sufficient vibration tests such that the total time under load is three times greater than any of the flight BDAs. Verify the performance of the test BDA.	Accepted	D. Crumb	10/15/2002	Currently evaluating test data provided by Europeans. Qual levels are 2.25 times higher and 2 times longer than the flight levels. We currently do not have a flight acceptance level. The 2.25 factor should be revisited to account for fatigue once the
16	The launch loads negotiated with Europe need to be clarified. The project is too far into development to still be unclear on the launch/test levels.	Clarify launch loads.	Accepted	T. Scharton	In work	We are currently negotiating levels down with the instrument and with ESA.
17	For each critical part, it is not clear what constitutes "worst case", fatigue life or load level.	Make a determination.	Accepted	K. Browning	Done	Analysis indicates that fatigue is no longer an issue.

Action Item Summary (4)

#	Statement of Concern	Recommended Action	Disp.	Responsible Individual	Status	Comments
18	Perform a modal analysis to determine which flavor of BDA location is worst-case. Establish what parameters determine worst-case for the suspension system, e.g. dyanmics peak acceleration versus frequency.	See Finding	Accepted	B. Winter (MSSL)	Done	Tim Larson has written memo.
19	The project needs to document how they are validating their flight design with their test program. Specifically, the cold test/warm test relationship was not clear.	The Board did feel that after some discussion, the project was on an acceptable path that needed crisper documentation.	Accepted	T. Larson	Done	Tim Larson recommends more cold vibration. There is a cost impact we are evaluating.
20	Vibration testing at 77K v. 4K is, in general, acceptable. However, the project needs to insure that the properties of the Kevlar braid at 77K is representative of conditions at 4K, or worse.	Document the test heritage with the approach from past programs.	Accepted	D. Crumb	9/13/2002	Dustin will issue a memo summarizing our collected data and how it applies to this issue.
21	Vespel has significant dimensional variation with humidity.	Its variation should be considered and evaluated in the current design.	Accepted	D. Crumb	9/13/2002	Dimensional change is very small (same as the manufacturing tolerance.)
22	Humidity can affect Kevlar.	Watch this variable	Accepted	T. Larsen		We launch under vacuum and we control the environment during testing. This is an issue potentially under warm vibration testing. Tim will call someone at Goddard who has the info and will write an email.