An Industry Perspective on Risk Status for a Hyperspectral Imager

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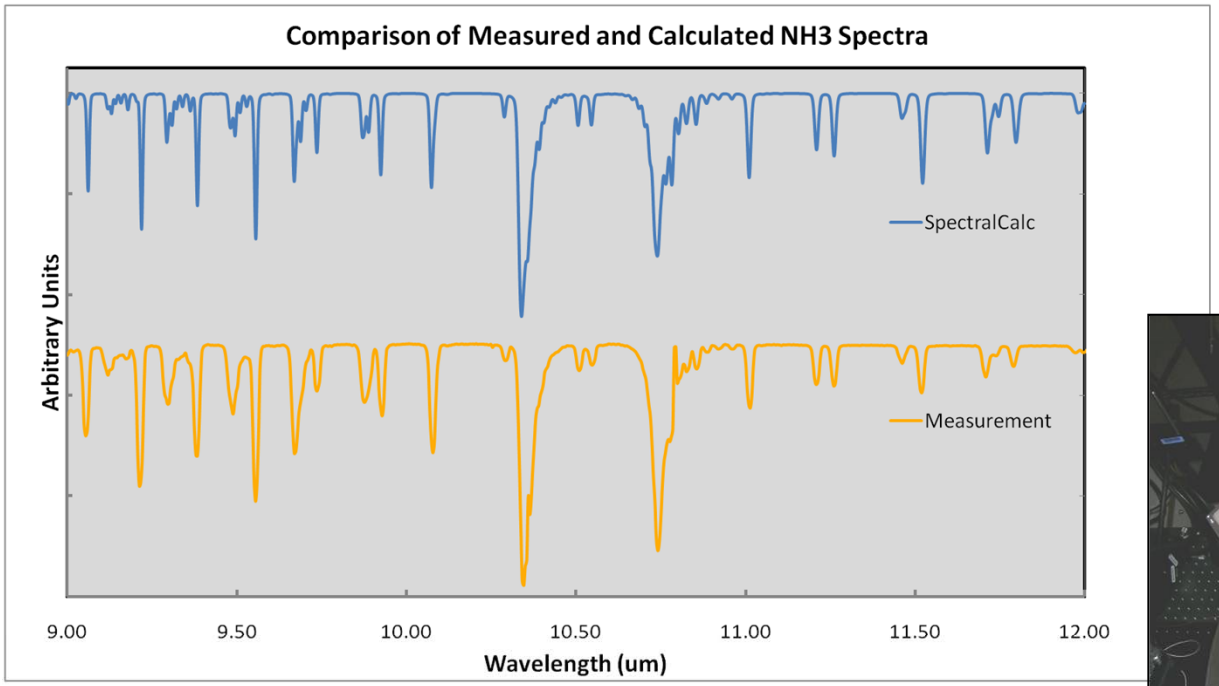
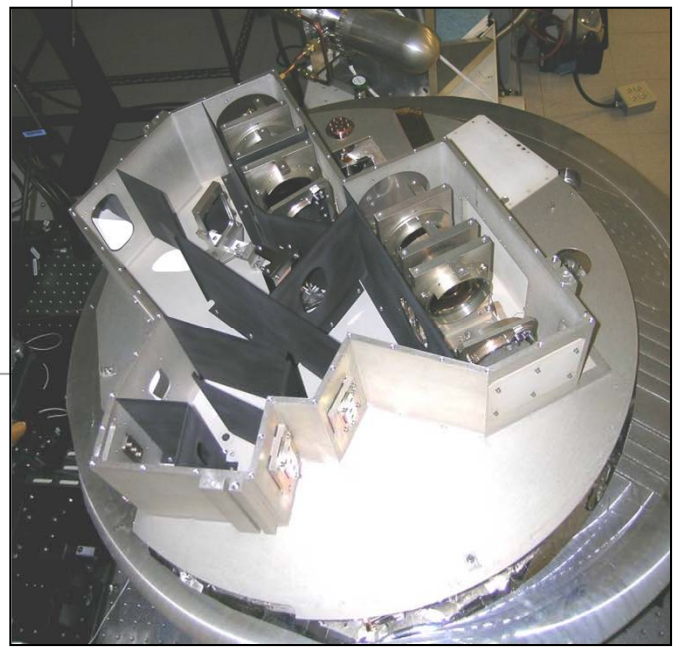
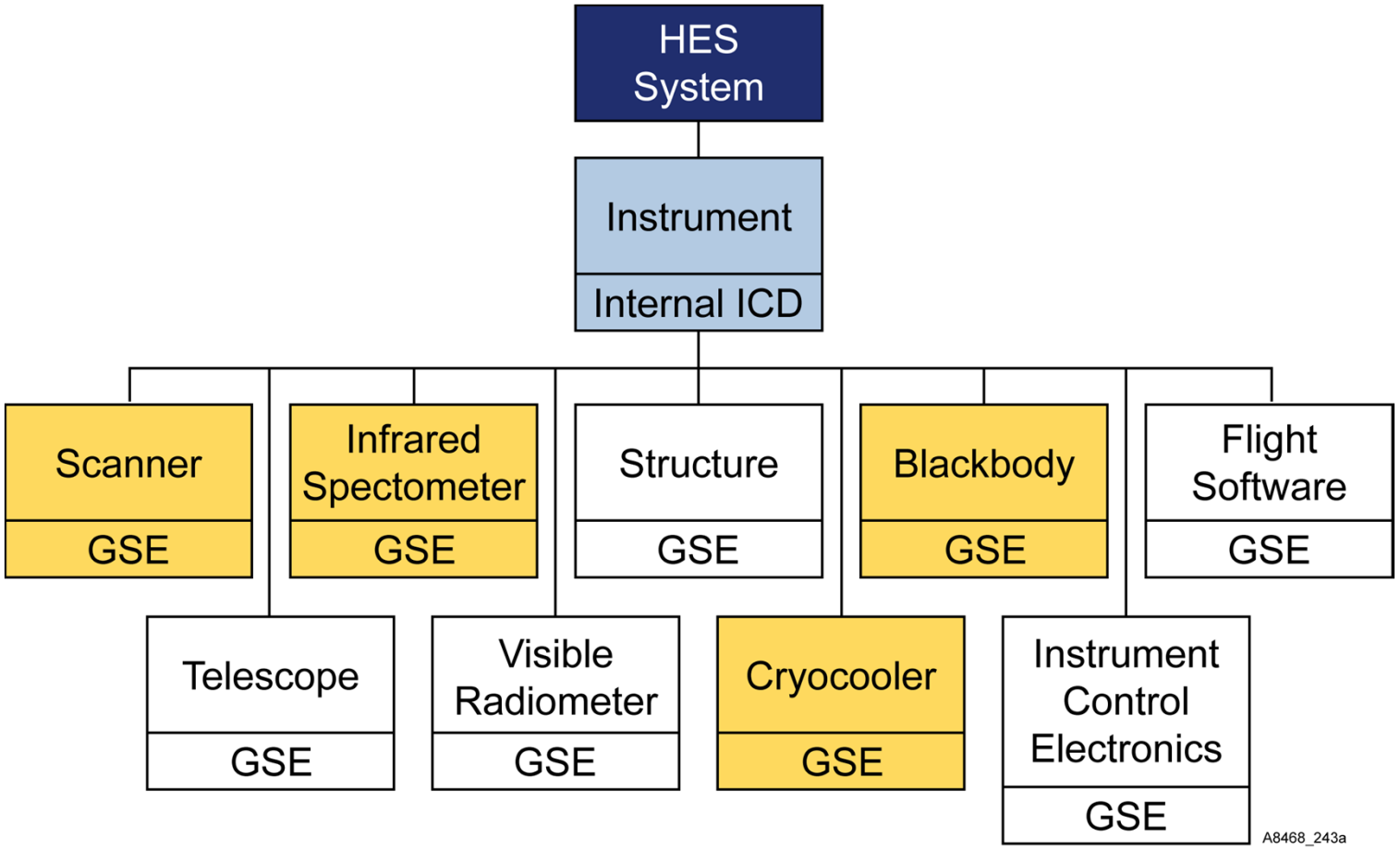
Key Technologies are No Longer High Risk



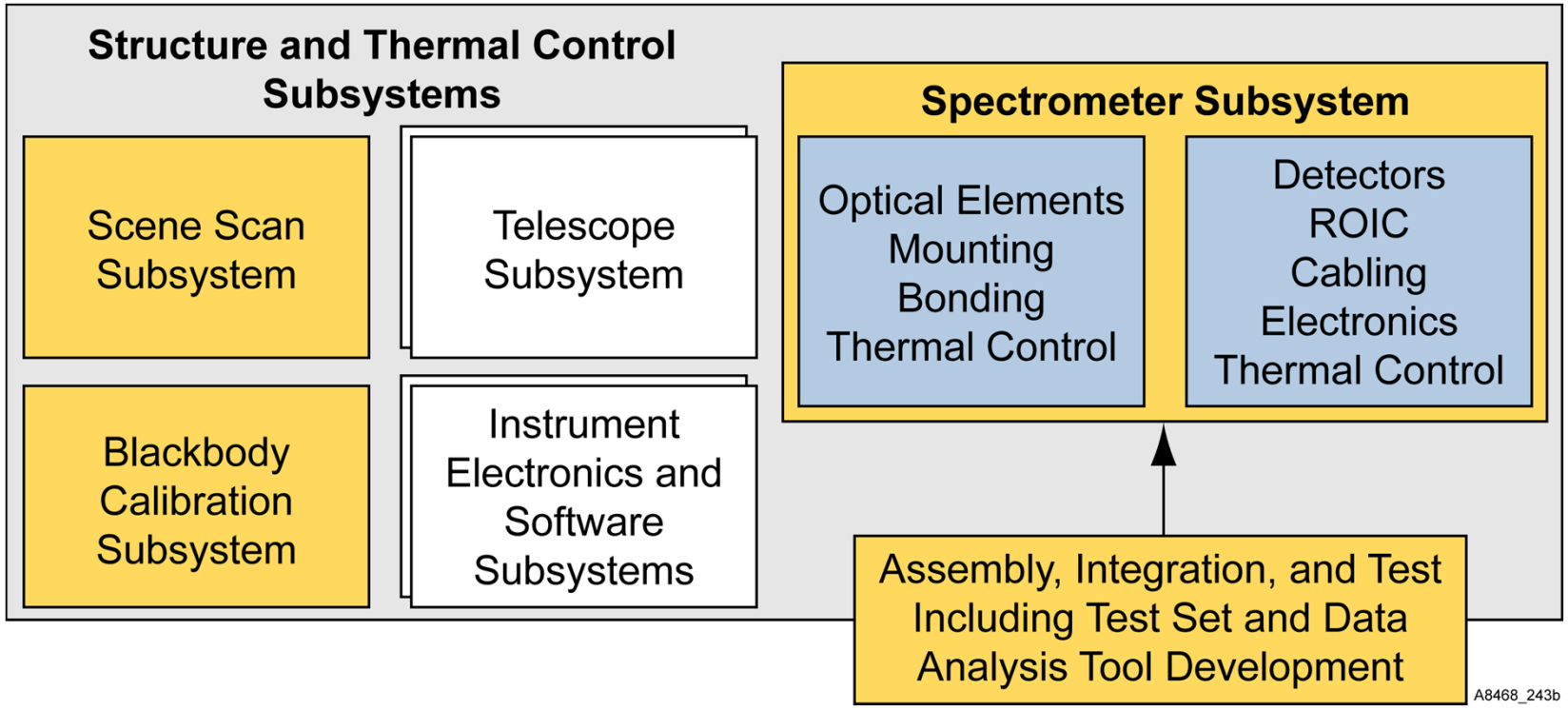


- GOES-HES Studies
- Industry Investments

Hardware Demonstrations Reduced the Risk of the Highest Risk Elements

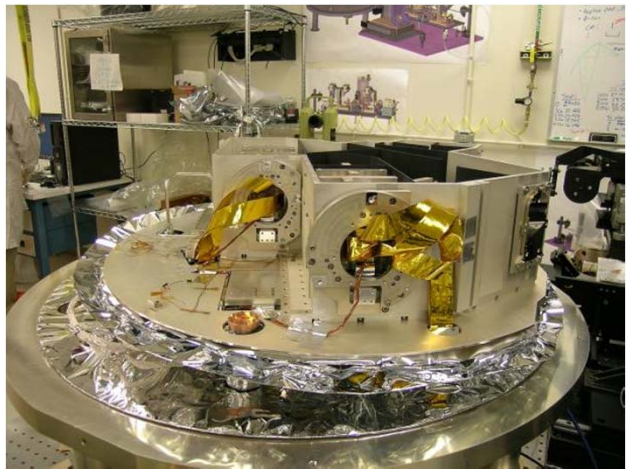


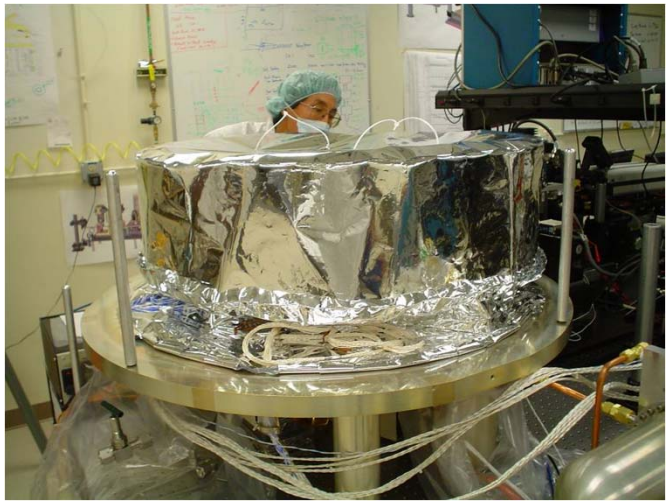
Flight-Like, Cryogenic Imaging Spectrometer Hardware Successfully Demonstrated



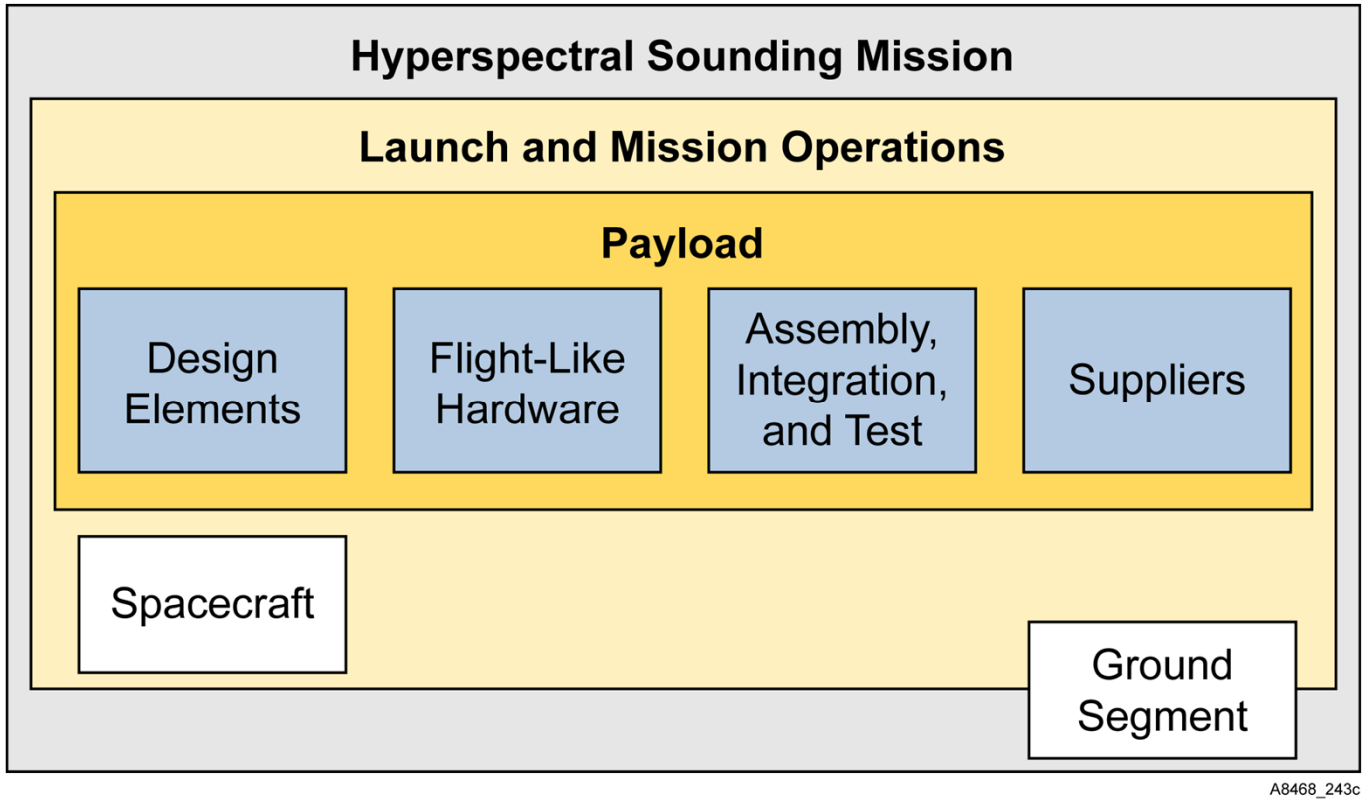
Ball Funded, Developed, & Tested Critical Subsystems

Subsystem	Project Guinness
Focal Plane Array	Spectrometer
Focal Plane Electronics	Spectrometer
Signal Cables	Spectrometer
Calibration	*
Spatial Scanner	*
Spectrometer Optics	Spectrometer
Thermal Control	Spectrometer
* Ball Aerospace GOES-HES study	





Program Elements Addressed by Project Guinness



Reference:
Efficient characterization of imaging spectrometers: application in the LWIR and MWIR
Author(s): Timothy J. Valle; Thomas U. Kampe; Paula R. Wamsley; Holden Chase; Glenn E. Taudien; Peter T. Spuhler; Peter B. Johnson; Gary L. Mills; Proceedings Vol. 7453 Infrared Spaceborne Remote Sensing and Instrumentation XVII

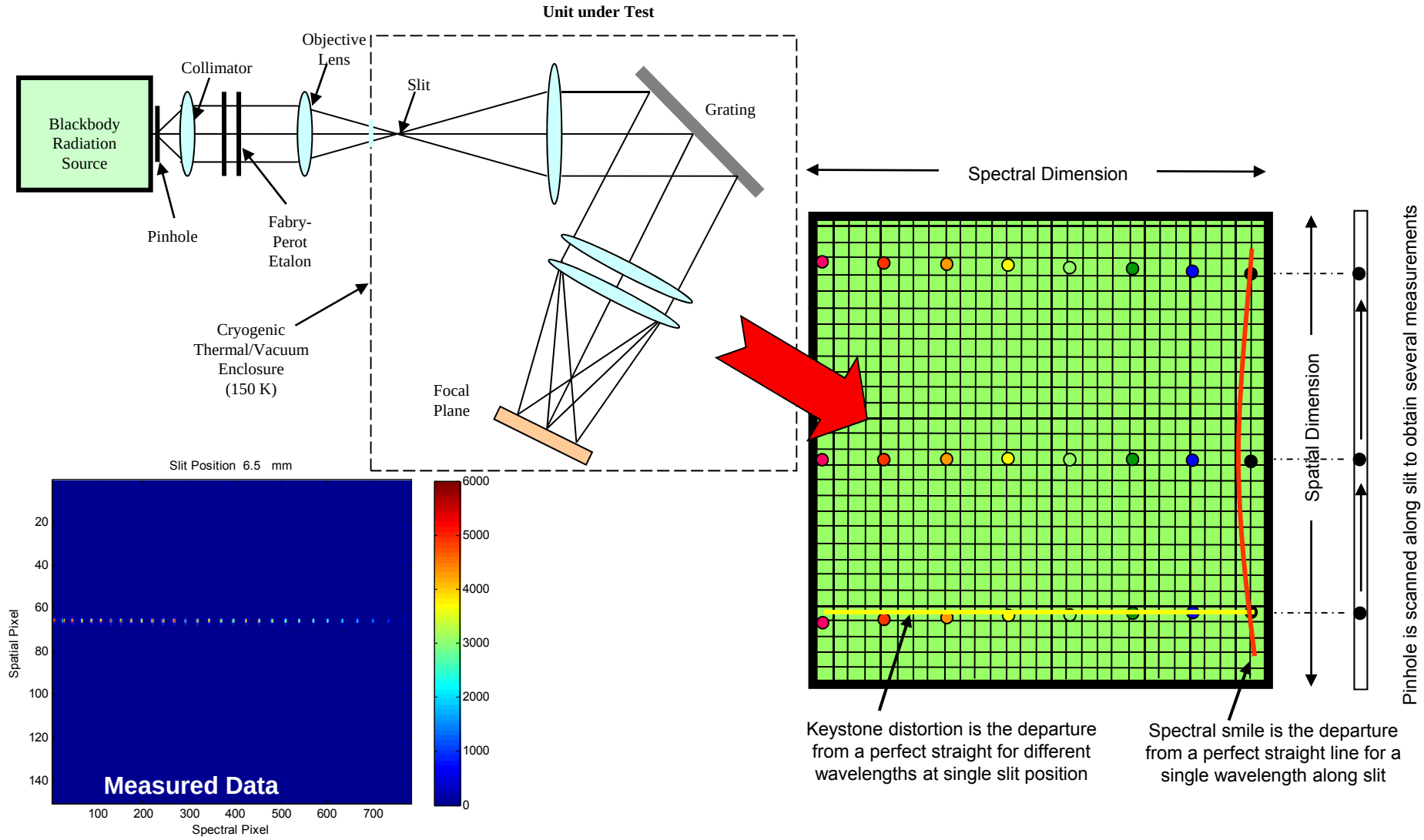
Spectrometer Design Risks Are Low

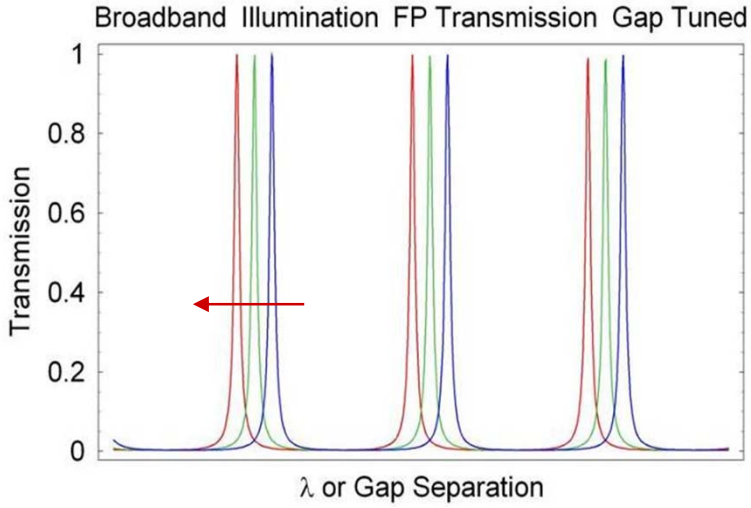
Design Element	Requirements	Risk Status
Electrical	➢ Low noise signal chain ➢ Cold focal plane array ➢ Warm electronics ➢ Data acquisition interface	Low
Optical	➢ Single slit, two channels ➢ Wavelength range: LWIR	Low
Mechanical	➢ Thermo-optical-mechanical stability	Low
Thermal	➢ Spectrometer at 100K ➢ Focal plane at 40K	Low
Assembly	➢ Components & mounts with built-in alignment features	Low
Test	➢ Co-registration of the two channels to 0.1 pixels	Low

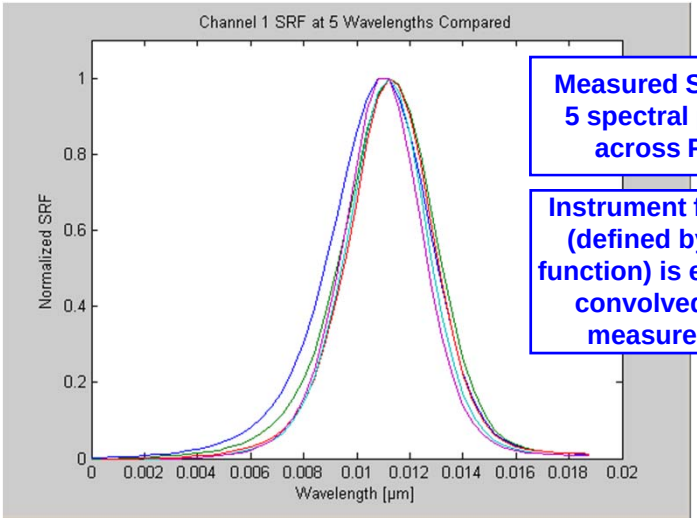
Hardware Risks Are Low

Hardware Element	Demonstration	Risk Status
Focal Plane Arrays	➢ Large format, LWIR cut-off, 40K operation	Low
Signal Cables	➢ Shielded, low noise cables with low thermal conductivity	Low
CdTe Lenses	➢ Bonding and mounting for survivability (temp range) and positional stability (op temp) of high transmission optics	Low
Diffraction Gratings	➢ Ruled, full size	Low
Collimator & Housing	➢ Mechanical stability from ambient to 100K	Low
Cryocooler	➢ Dual temp stages, thermal bus, no impact on noise (electrical) or mechanical stability of the spectrometer	Low

Fabry-Perot Test Methodology Provides Efficient Measurement of Key Performance Parameters

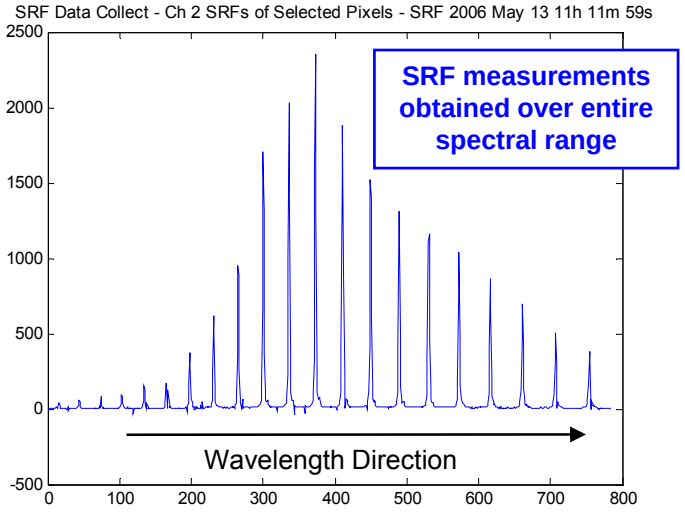






Measured SRF for 5 spectral pixels across FPA

Instrument function (defined by AIRY function) is easily de-convolved from measurement



SRF measurements obtained over entire spectral range

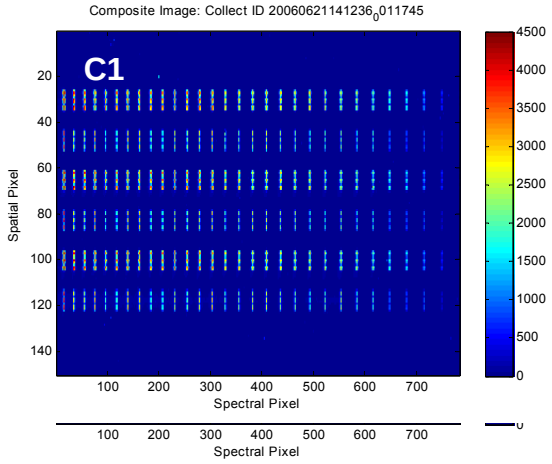
Assembly, Integration, & Test Risks Are Low

AI&T Element	Demonstration	Risk Status
Built-in Alignment Features & Compensators	➢ Spectrometer aligned and tested in 4 cycles over 2 months	Low
Alignment	➢ Slit to grating to dual focal planes ➢ Magnification of each channel ➢ Focus ➢ Reproducibility over multiple cycles	Low
Test Set Development	➢ Vacuum chamber and thermal control ➢ Design & development (electrical, optical, mechanical, & thermal) ➢ Critical X,Y,Z alignment ➢ Tunable Fabry-Perot development for LWIR ➢ Automated data acquisition software	Low
Test & Data Analysis Software	➢ Keystone Distortion ➢ Smile Distortion ➢ Modulation Transfer Function ➢ Spectral Response Function	Low

Supplier Risks Are Low

Hardware Element	Risk Status
Focal Plane Arrays	Low
Focal Plane Electronics	Low
Cryo-vacuum Signal Cables	Low
Diamond Turned Optics	Low
Housing & Mounts	Low
IR Optics	Low
Diffraction Grating	Low
Optical Coatings	Low
Cryo-cooler	Low
Black Body	Low

Completed Risk Reduction Activities Are Still Relevant



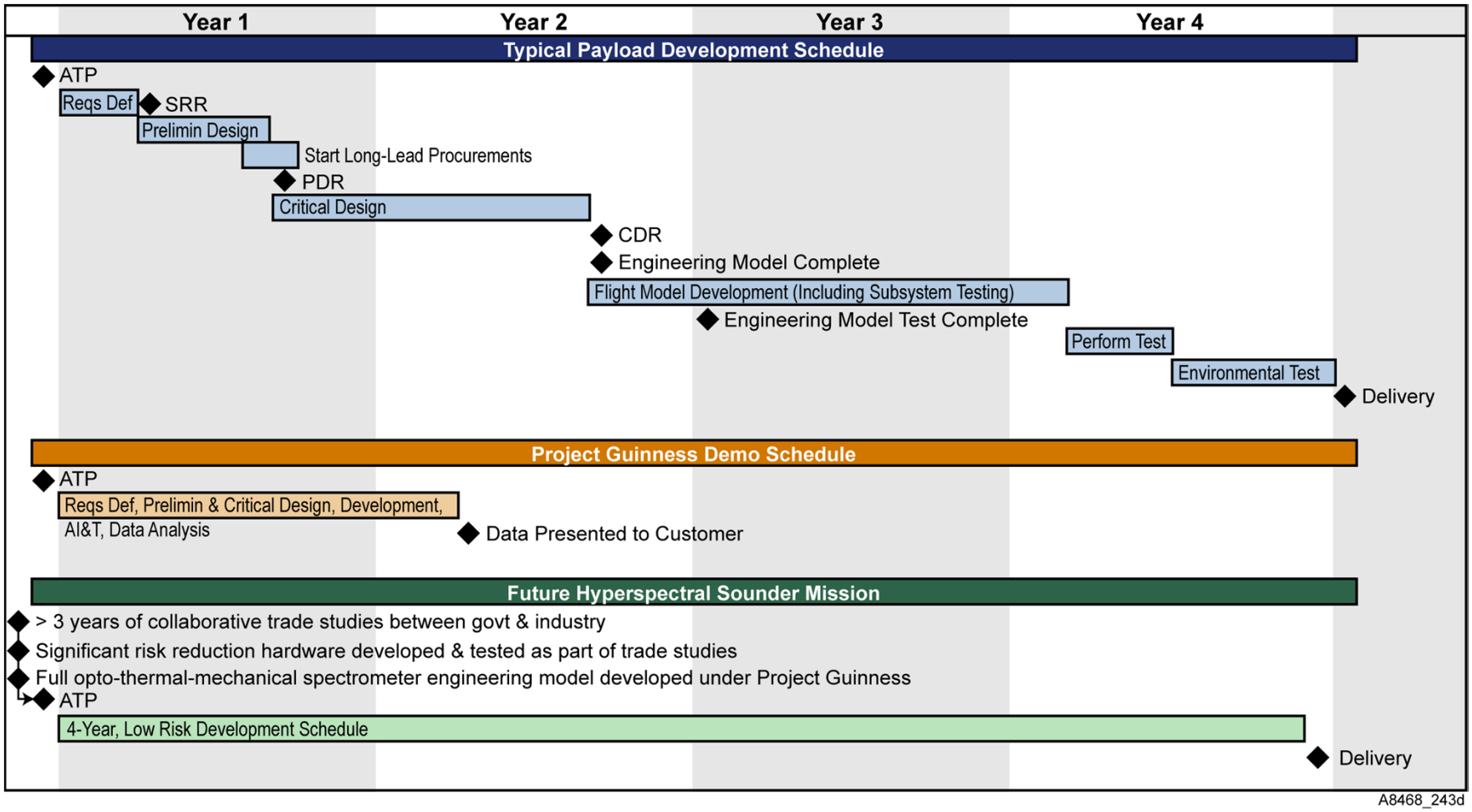
- **Ball Aerospace designs are modular and therefore flexible to requirements changes**
  - **Detailed requirements typically flow down to component specification**
  - **Component specifications are not at their manufacturing limits**
- **Designs meet requirements with margin**
- **Designs kept pace with evolving GOES-HES requirements**

	Spectral Position (pixel)	Spatial Position (pixel)	Spectral Position (pixel)	Spatial Position (pixel)
C1	50	121.73	50	28.01
C2	50	121.66	50	28.07
Delta		**0.07**		**0.06**
C1	736	121.75	736	28.08
C2	736	121.72	736	28.07
Delta		**0.03**		**0.01**
Maximum Co-Registration Delta:			**0.07 pixels**	

Investments Are Still Relevant to Future Missions

Subsystem	Relevance	Comments
Focal Plane Array	High	➢ OK for dimensions ≤ demonstration size ➢ OK for changes in spatial (N) x spectral (M) format ➢ OK for dual hybridization ➢ OK for wavelengths ≤14μm ➢ Flight ROIC design (LDCM/OLI)
Focal Plane Electronics	High	➢ OK for FPA format changes ➢ OK for high voltage biases ➢ Flight electronics design (LDCM/OLI)
Cryo-vacuum Cables	High	➢ OK for lengths up to demonstration length ➢ OK for various mounting config ➢ Flight cable design (LDCM/OLI)
Optical	High	➢ OK for wavelengths ≤14μm ➢ OK for different wavelength break points ➢ OK for spectral resolution changes ➢ OK for spectral bandpass changes
Mechanical	High	➢ OK for similarly sized optics and optical materials
Thermal Control	High	➢ Existing cryocooler has cooling capacity and good electrical and mechanical noise properties

Investments Enable Low-Risk Schedule



Conclusion

Key Technologies Are No Longer High Risk