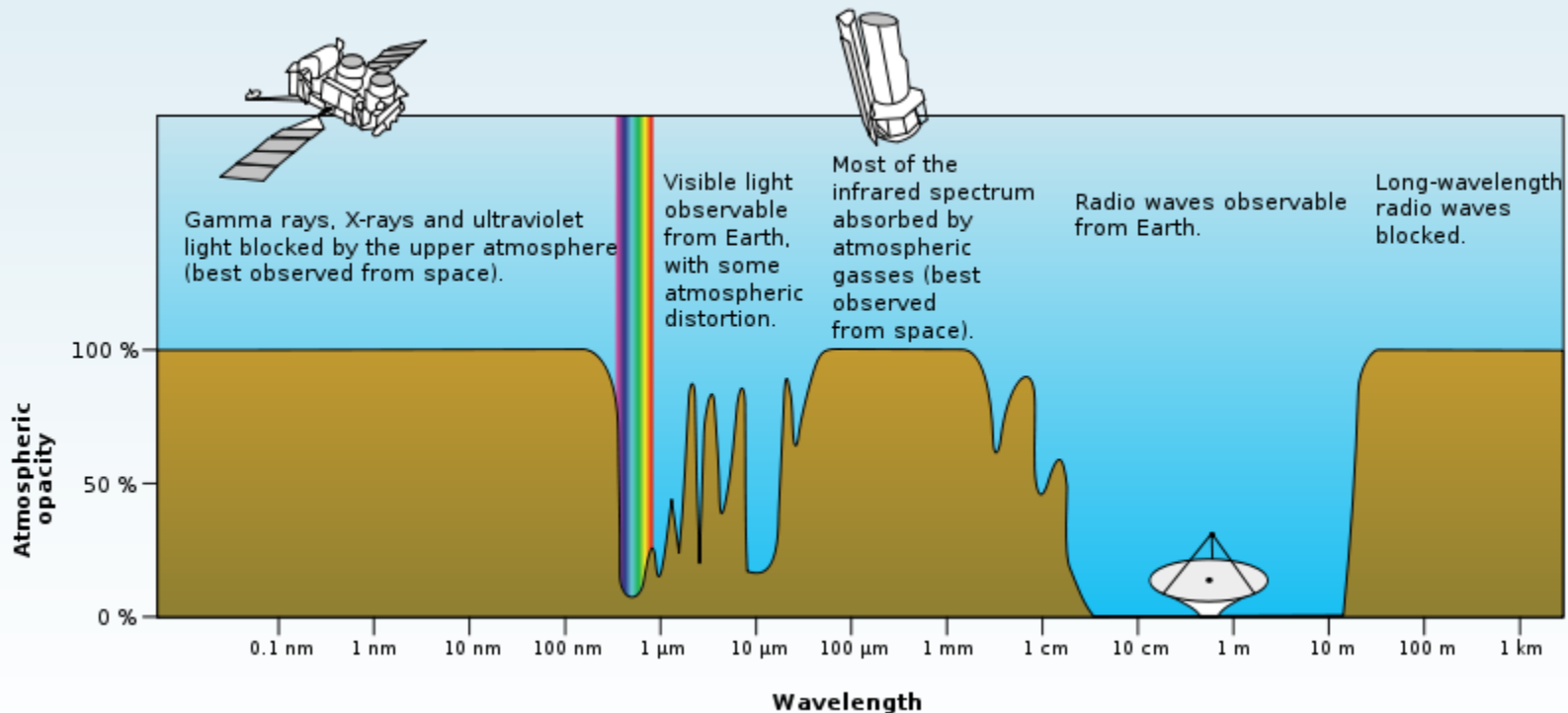





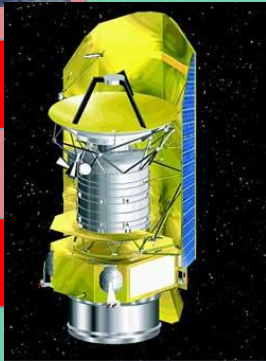


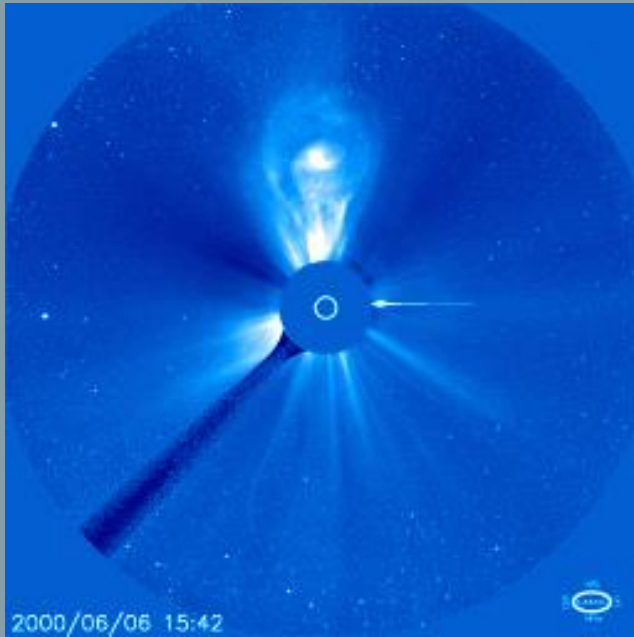
Sensors in Space

Professor Alan Smith
Director Mullard Space Science Laboratory
University College London
alan.smith@ucl.ac.uk

The Transparency of the Atmosphere



	v-ray	X-ray	UV	Visible	NIR	FIR
Scintillator						
Calorimeter						
MCP						
CCD, CMOS						
ICCD, IAPS						
BOLD						
STJs						
Bolometers						
Photodiodes						
Semiconductors						
Coherent detector						
Heterodyne						
Radiometers						

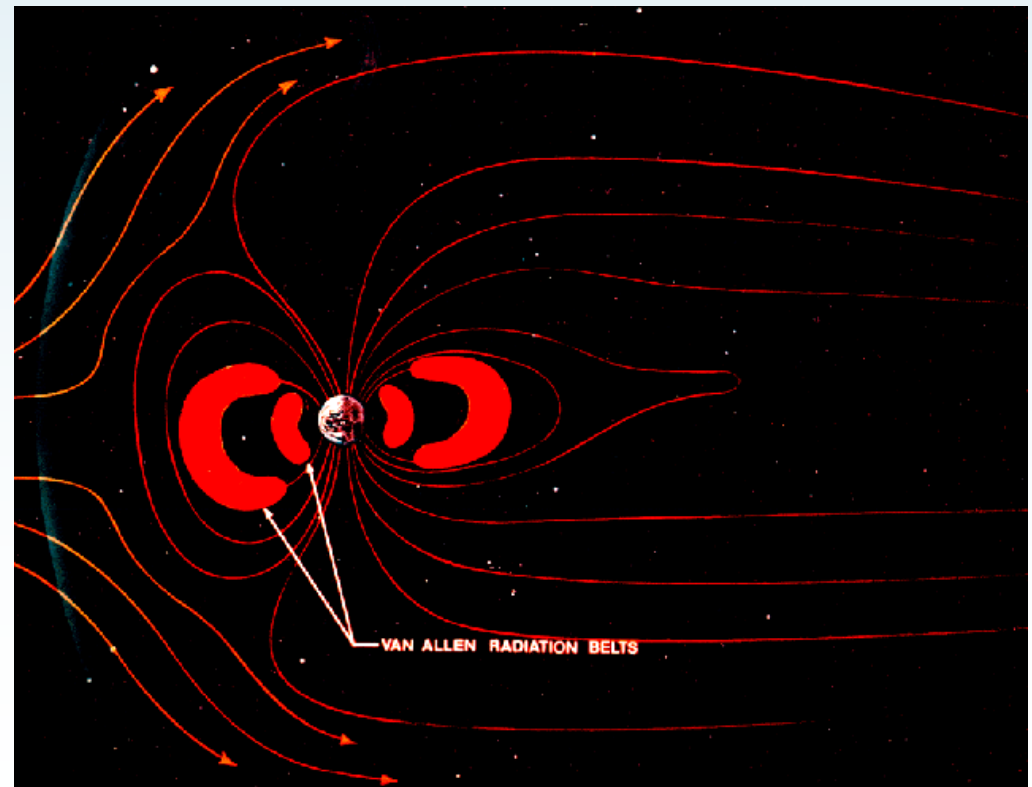


Technological Challenges

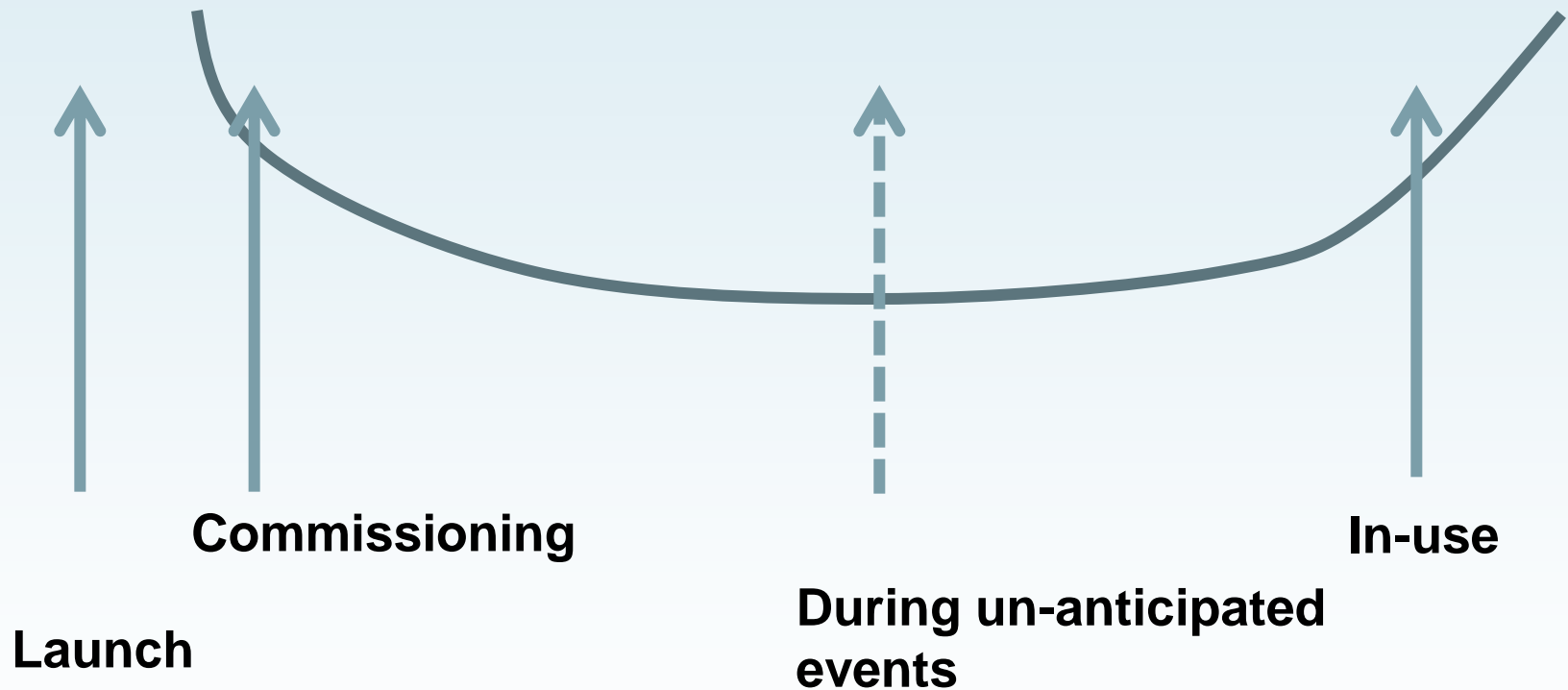


Some specific environmental challenges

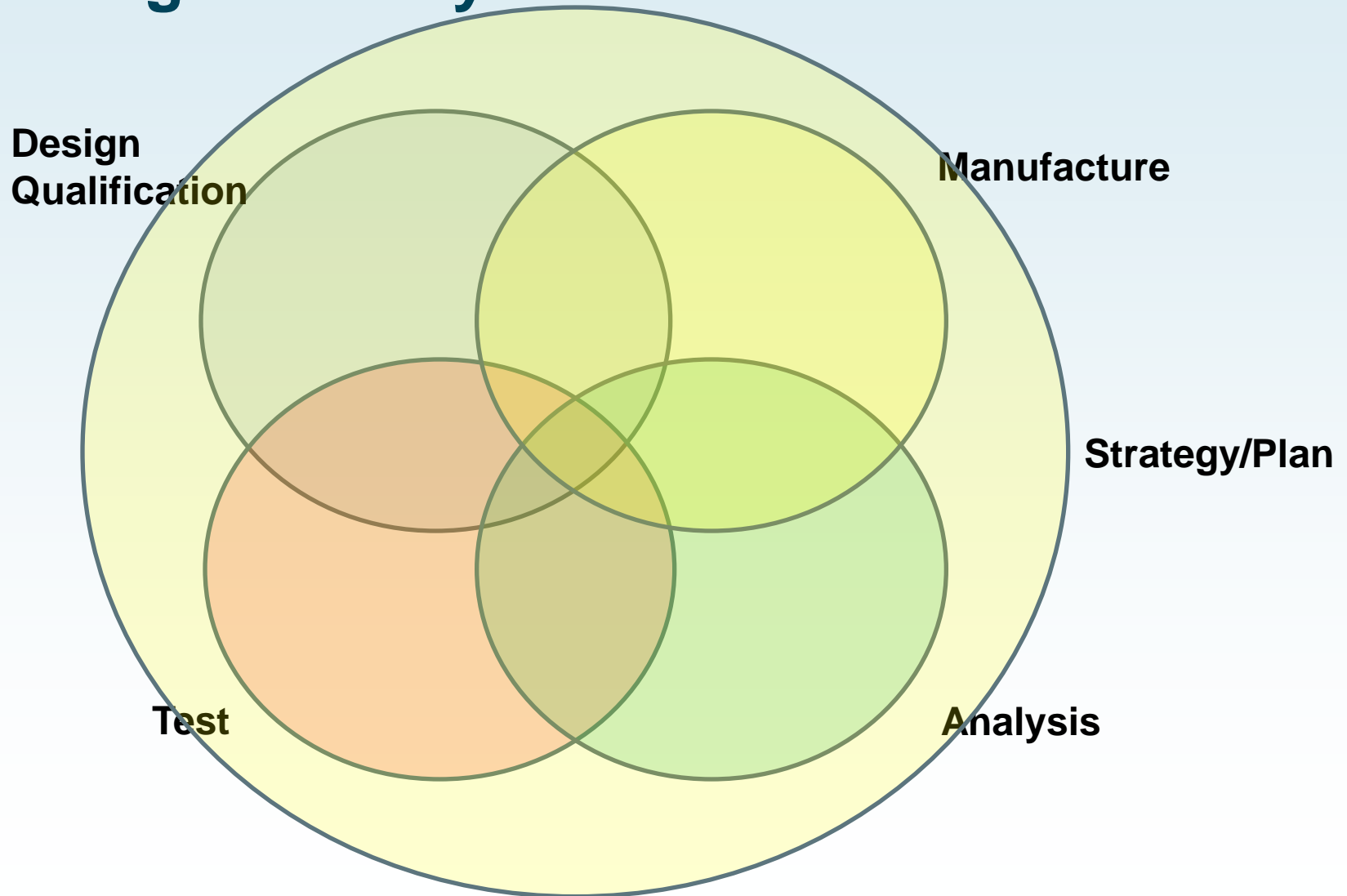
- Launch vibration and shock
- Thermal balance
- Ionizing radiation
- Stray-light
- Micro-vibration
- Contamination



When do things fail?



Ensuring reliability

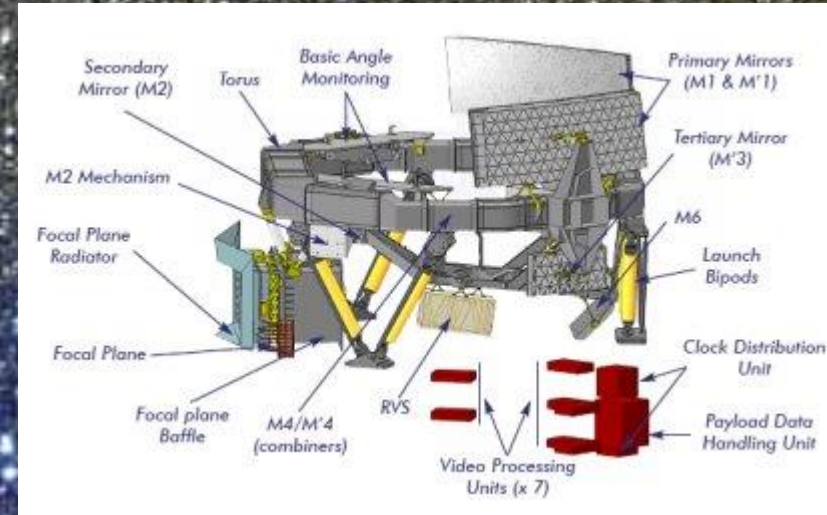
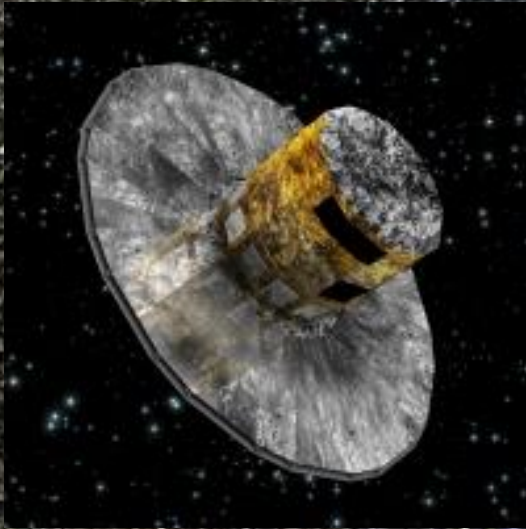


The Butterfly Nebula

From NASA's
HST Wide Field
Optical Camera



ESA's GAIA – launched 19 Dec 2013



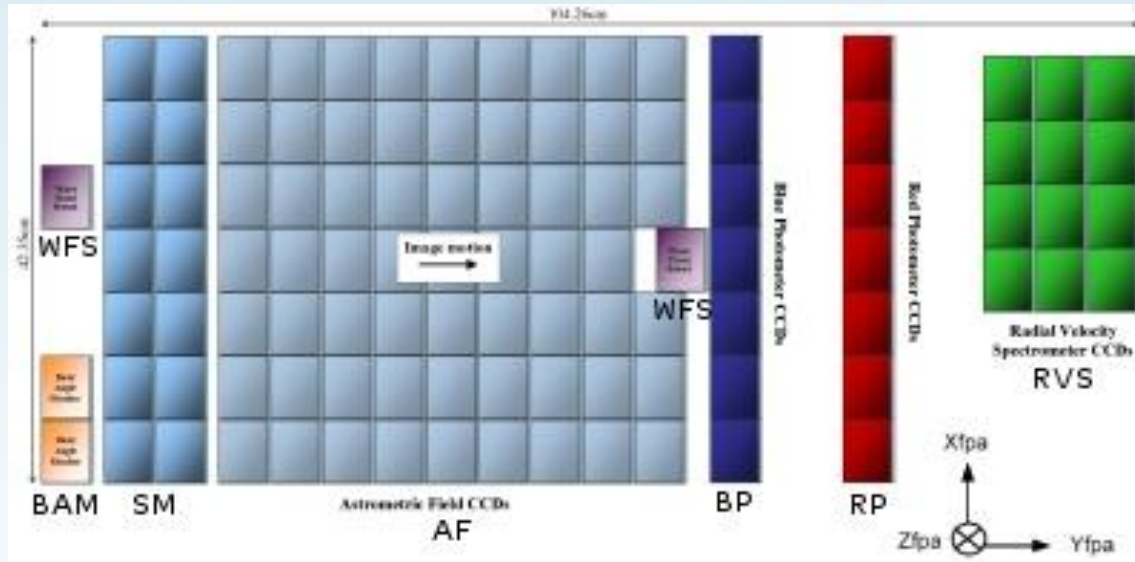
A space mission to measure with unprecedented accuracy the position and radial velocity of 1,000,000,000 stars – to create the first 3-D map of our galaxy

To understand how our galaxy formed and how it will evolve

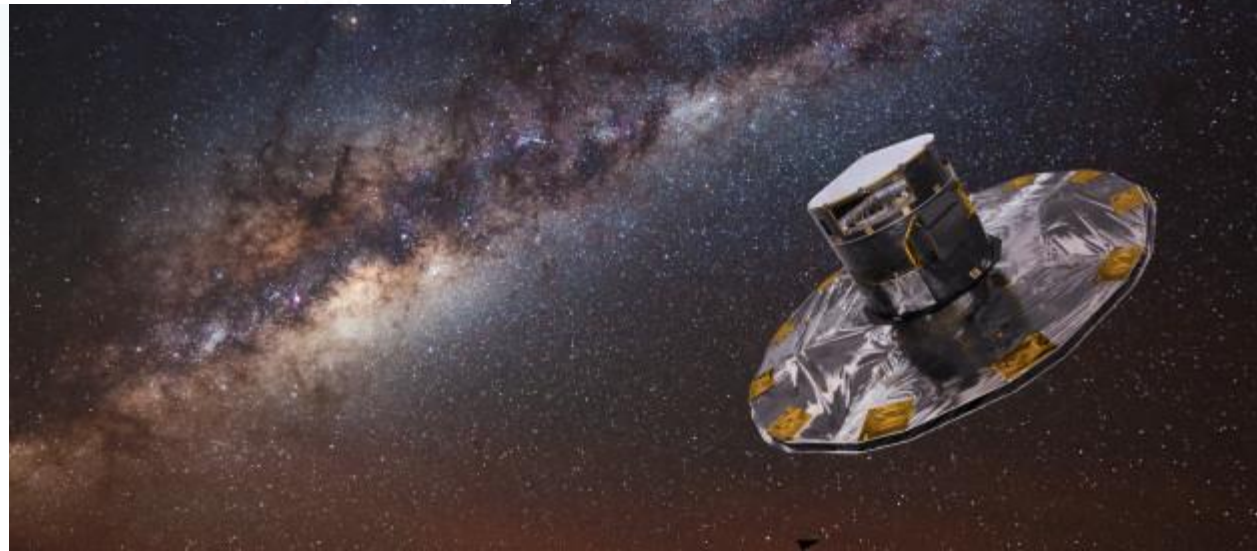
Case Study – Gaia CCDs



Largest focal plane flown in space

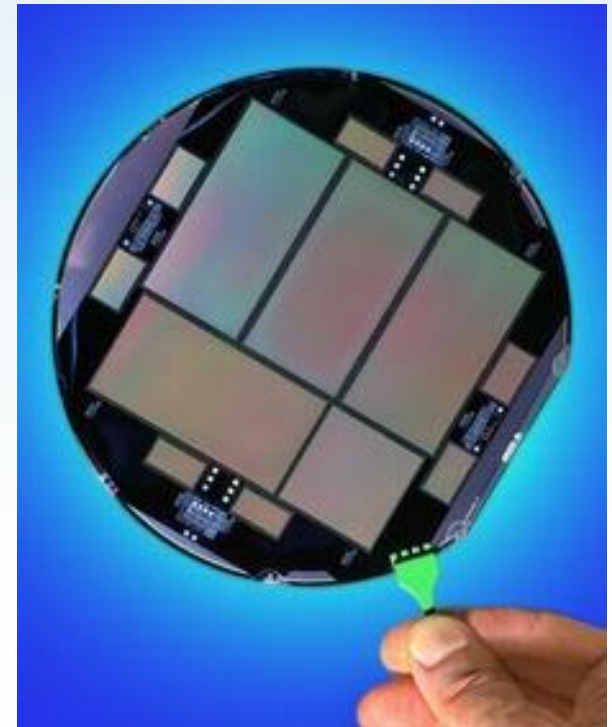


106 CCDs
~ 10^9 pixels



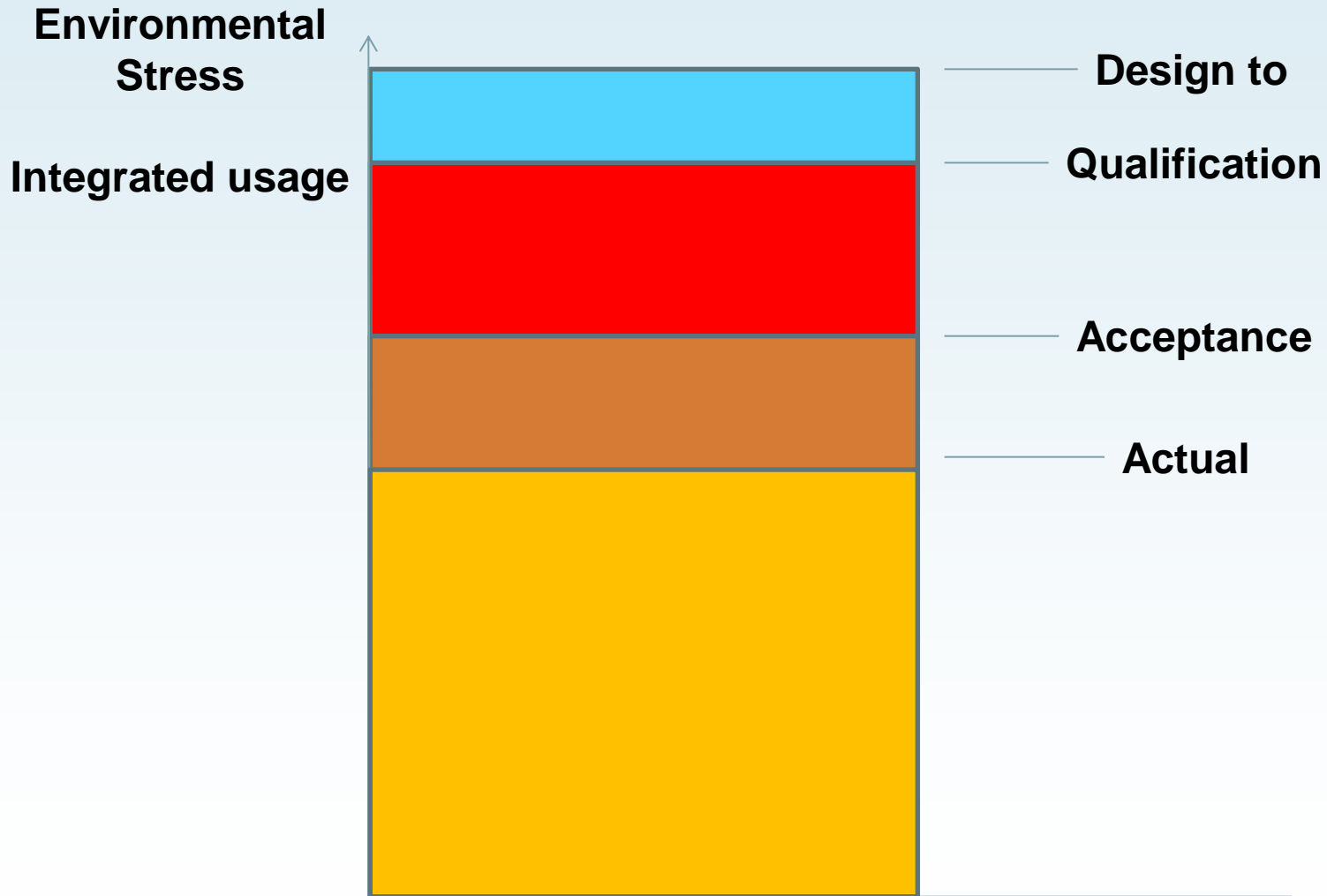
Manufacturing

- CCD production is highly process driven
- Industry productivity demands high yield from a many stage process
- Process oversight and KIPs (facility and device) are essential



CCD wafer
Lawrence Berkeley
National Labs

Qualification



Progress towards qualification

Lifecycle event	Requirement	Concept Definition	Design prediction	Breadboard	Engineering Model	Qualification
TRL			3	4	5	6
Charge transfer efficiency	99.998 %	99.9995	99.999	99.9975	99.9983	99.9987
Readout noise	3 e ⁻	2.5 e ⁻	2.6 e ⁻	4.5 e ⁻	3.9 e ⁻	3.6 e ⁻
Peak Quantum efficiency	88 %	92 %	90 %	86 %	88 %	89 %

Test



Analysis

- Normally performed through a process of abstraction and modelling
 - Electrical – as in electronics
 - Electronic – as in electron mobility
 - Thermal
 - Structural
 - Contamination
 - ...

**Integrate analysis
and modelling up
through the
system hierarchy**

Test

- Test everything that can be tested and test at every level of integration
- Test and analysis must concur



Test facility used for GAIA CCDs at MSSL

Beyond Test

- Characterise and understand the underlying physics of the devices
 - => predict performance in novel situations
 - => optimise
 - => deal with issues seen in flight
 - => understand the data better



Robust and Resilient

- Robust
 - Demonstrated design margins
 - Management of use through:
 - usage strategies
 - usage budgets
- Resilience
 - Redundancy
 - Re-programmable, flexible
 - Re-configurable

