Technology Roadmapping

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Technology Categories

- Telescopes/mirrors
- Structures
- Detectors
- Coatings
- Multiplexing: microshutter arrays, micromirror arrays, integral field units
- Instrumentation optics (Gratings, optical surfaces, spectrometers, etc.)
- Other: electronics, cryogenics, thermal, telemetry

Technology Figures of Merit

- 1. Current and projected (2020, assuming funding as specified below) performance.
  - e.g., for detectors: QE vs. wavelength, internal/dark noise, photon-counting capability, number of pixels/formats/scaleability, energy resolution, dynamic range.
- 2. Implementation and operational issues/risks:
  - e.g., for detectors requirements for cooling, high voltage, required materials/process improvements, red leak/out of band response.
- 3. Cost/time to TRL-6 and leverage:
  - What is the current TRL level, what NASA funding and time is required to reach TRL6,
  - What is the degree of difficulty of these developments
    - for example using the DOD Degree of Difficulty scale
  - What non-NASA astrophysics division resources can be brought to bear to leverage the development>
    - significant industrial involvement and prior investments, cross-division, cross-agency, private-sector investments and applications, existing infrastructure and institutional investment
- 4. Relevance to and impact on possible future missions:
  - Large 4-8 m UVOIR general astrophysics missions, Far IR/Sub mm missions
  - Joint Exoplanet imaging missions & required compatibility technologies

Technology Readiness Level

- TRL 1. Basic principles observed and reported.
- TRL 2. Technology concept and/or application formulated.
- TRL 3. Analytical and experimental critical function and/or characteristic proof-of-concept completed.
- TRL 4. Component and/or breadboard validated in laboratory environment.
- TRL 5. Component and/or breadboard validated in relevant environment.
- TRL 6. System/subsystem model or prototype demonstrated in a relevant environment (ground or space).
- TRL 7. System prototype demonstrated in a space environment.
- TRL 8. Actual system completed and "flight-qualified" through test and demonstration (ground or flight).
- TRL 9. Actual system "flight-proven" through successful mission operations.

DOD Degree of Difficulty

- **I. Very low degree of difficulty** anticipated in achieving research and development (R&D) objectives for this technology; only a single, short-duration technological approach needed to be assured of a high probability of success in achieving technical objectives in later systems applications.
- **II. Moderate degree of difficulty** anticipated in achieving R&D objectives for this technology; a single technological approach needed; conducted early to allow an alternate approach to be pursued to be assured of a high probability of success in achieving technical objectives in later systems applications.
- **III. High degree of difficulty** anticipated in achieving R&D objectives for this technology; two technological approaches needed; conducted early to allow an alternate subsystem approach to be pursued to be assured of a high probability of success in achieving technical objectives in later systems applications.
- **IV. Very high degree of difficulty** anticipated in achieving R&D objectives for this technology; multiple technological approaches needed; conducted early to allow an alternate system concept to be pursued to be assured of a high probability of success in achieving technical objectives in later systems applications.
- **V.** The degree of difficulty anticipated in achieving R&D objectives for this technology is so high that a **fundamental breakthrough in physics, chemistry**, and so on is needed; basic research in key areas needed before system concepts can be refined.

Detector FOM Summary

KISS UV Technology Workshop

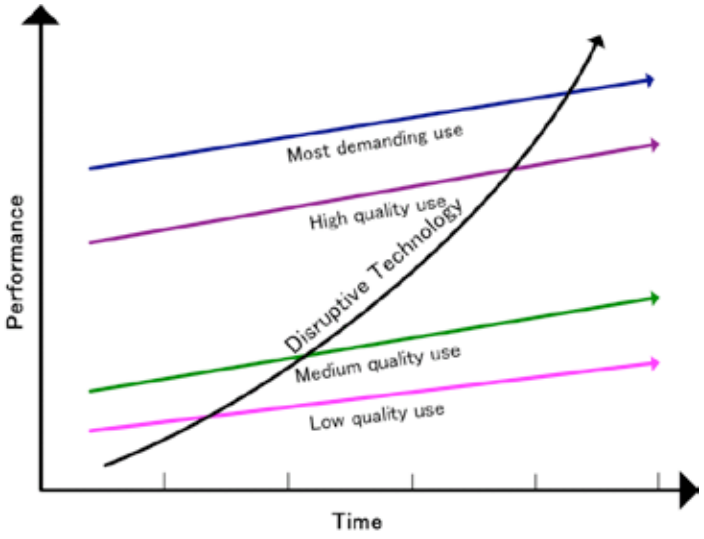
Detector	Band [nm]	QE [nm] 100|150|250	# pixels	PC	Dark	OOB	DE	RadTol	Lever	Imp Iss	CT6	TRL
BoSi MCP	<1000	40 | 25 | 8	>10^8	YES	3	3	1	3	2	HV, tube	3	~4
BoSi MCP+GaN	<300	* | 50 | 36	>10^8	YES	3	2	1	3	2	HV, tube	2	~3
EBCCD+GaN	<300	* | 55 | 40	3e7 (sp) 2e6 (Im)	YES	3	2	1	2	1	HV, tube	1-2	2-3
ARDDEMCCD	<1000	45 | 55 | 55	10^8 - 10^9	YES	3	1	1	2	3	Cold, cont	3	4
SPAD-CMOS-Si	<1000	35 | 55 | 55	10^8	YES	1	1	1	3	3	Cold, cont	1-2	1
MKIDS	<6000	30 | 75 | 75	64^2	YES	3	3	3	3	2	Cold, complex, power	1	2
AlGaN APD	<300	* | 50 | 50	0 --> 10^6	YES	1 --> ?	2	1	2?	2	Cold, hybrid	1	1
AlGaN PIN	<300	* | 50 | 50	256^2 --> 10^6	NO	1 --> ?	2	1	2?	2	Cold, hybrid	1	1

Disruptive Innovation

- Ingredients
  - Questioning
  - Experimenting
  - Observing
  - Associating
    - linking concepts from diverse fields
  - Networking
    - to search for new ideas

see UNBOXED, Steve Lohr, Sunday 8/28/11 NYT

- Examples
  - e-Book (p-Book)
  - digital cameras (film)
  - PC (mainframe)



The Business Model

- 2 Strategies
  - Entreprenuerial
    - Decisions/rankings made by peer review panels
    - PI vs. PI
    - Natural selection
      - (or species extinction)
  - Collective/collaborative
    - Community speaks with one voice
    - Self-organized
    - e.g., Decadal Surveys

Exoplanets, Dark Energy