

우주망원경의 기술적 접근 (국내역량탐색 및 해외사례)



Knowledge
Absorb
Superior
Innovation

2020.12.04

천문우주기술센터, 한정열



- **국내역량 탐색**
 - 국내 산학연 망원경기술개발 모임 및 교류 소개
- **국외 대형우주망원경(LUVOIR) 사례**

국내 산학연 망원경 기술개발 모임

■ 목적

- 우주망원경의 기술적 개발 역량 파악
- 국가기반 우주망원경 기획연구 참여

■ 기술 역량 탐색분야

- 망원광학계 및 관측기기 개념설계
- 광학, 광기계, 제어 설계
- 소재개발
- 광학면 연마 및 측정
- 광학계 조립, 정렬 및 성능평가
- 시스템 엔지니어링

■ 관측목표 탐색

- 우주망원경 관측주제: 학계 및 연구계
- 국외 탐색주제: 국외 개발계획 참조

■ 취지

- 사회에 기여하는 초융합연구 - 역량결집
- 대학: 기초연구, 인력양성
- 기업; 생산, 고용창출
- 연구소: 응용연구, 국가적 융복합 연구
- 천문연: 우리는 우주의 근원적 질문에 과학으로 답한다

■ 모임 진행 단계

- 의견수렴
- 기관역량 공유
- 포트폴리오 구성
- 참여기관 모임, 자문위원회 구성
- 기획보고서 작성
- 핵심 요소기술 개발

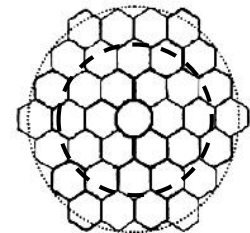
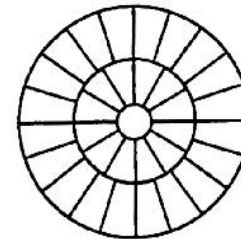
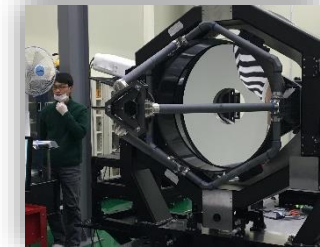
망원경 사양 탐색 (진행중)

■ 현 수준

- 1 m 급 축대칭 망원광학 탑재체
- 관측파장 및 기기
 - . 적외선 경험 (MIRIS; 다목적 적외선 영상관측 시스템, NISS; 근적외선 영상분광기)
 - . 자외선 경험 (FIMS; 원자외선 영상분광기)
 - . 가시광선 및 적외선 (과학임무)

■ 망원경 사양 탐색 (향후 10년 개발 가정)

- 주반사경 크기: 3.5 m (0.7 m x 19ea) / 2.1 m (0.7 m x 7ea)
- 반사경 형태: **조각거울** vs. 단일경
- 광학계 형태: **축대칭** vs. **비축**
- 관측기기: 코로나그래프, 이미저, 분광기, 분광편광기 등
- 파장: **UV**, O, IR, THz(?)



STACK: Space Telescope from Advanced Composition in Korea
→ 기술축적을 통한 우주망원경

포트폴리오 구성(진행중)

기업/대학/기관	연마	연마 수준	연마 장비	1차 가공 여부	본딩	광기계	경량화율	비축 반	조각	에칭	소재	측정	Verifi	Coati	Towe	Priority	Technology Gap Name	TRL
																1	Ultra-stable Opto-mechanical Systems	2
KBSI	1.2 m (polishing)	DTM / 1.2 m MRF	Q-Flex 1200	O				1.2	1.5							1a	Segment Phase & Control	3
																1b	Dynamic Isolation Systems	4
																1c	Mirror Segments	5
																2	High-contrast Segmented Aperture Coronagraphy	3
																2a	Segmented-aperture Coronagraph Architecture	3
																2b	Deformable Mirrors	4
																2c	Wavefront Sensing & Control	4
																2d	High-contrast Imaging Post-processing	4
																3	High Performance UV/Vis/NIR Detectors	
																3a	Large-format High-dynamic Range UV Detectors	4
																3b	Ultra-low Noise Detectors for Visible Exoplanet Science	5
																3c	Ultra-low Noise Detectors for NIR Exoplanet Science	5
																4	Next Generation Microshutter Arrays	4
																5	High Reflectivity Broadband FUV-to-NIR Mirror Coatings	3
																Y&DK		

- 요소기술 및 기술수준(TRL) 식별
- 기술별 개발계획 및 확보전략 수립
- 단계 식별 및 적용성 환경 테스트

Stability for high-contrast is #1 challenge
 “~10 pm RMS per ~10 minutes”

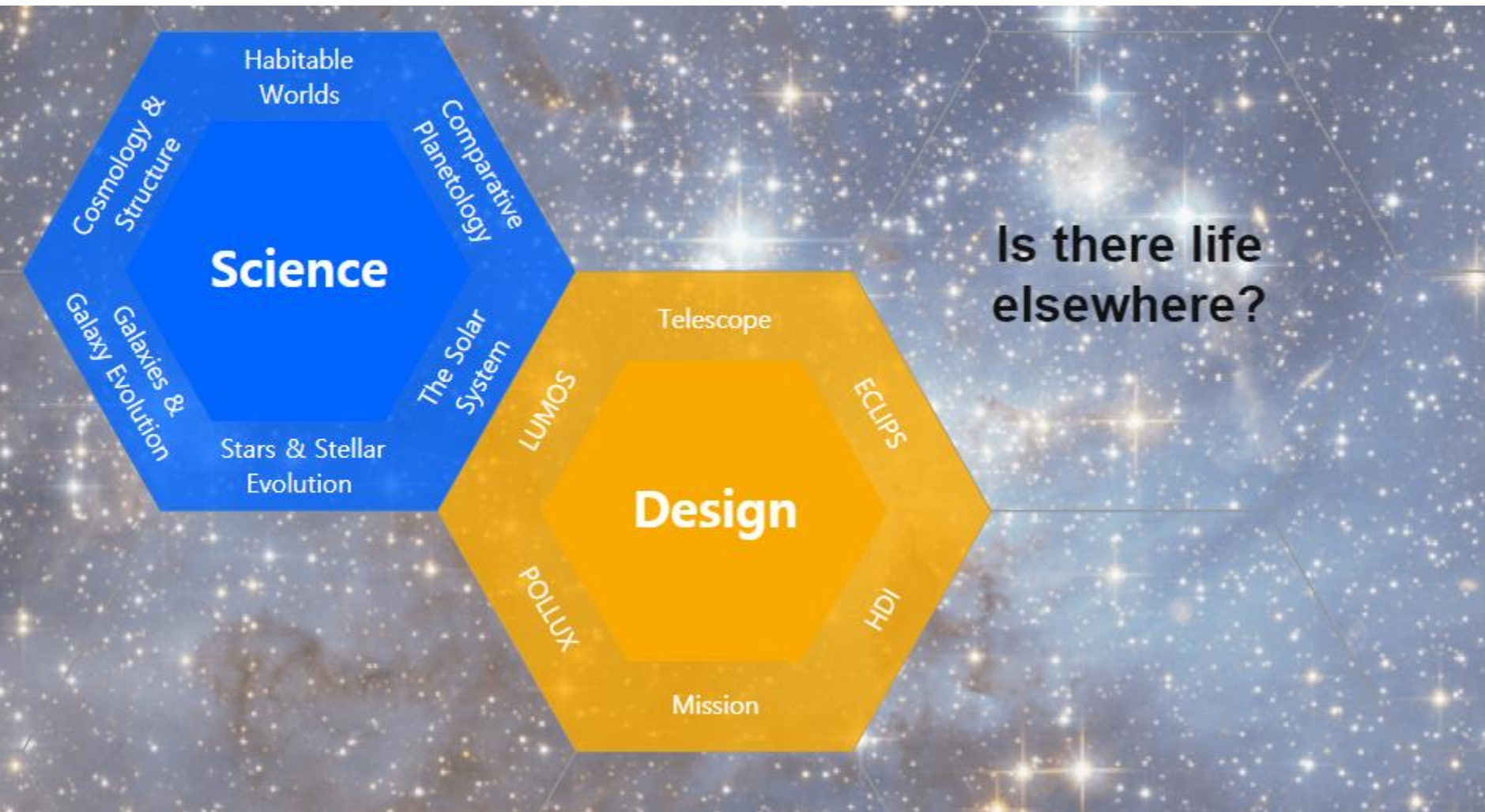
- High-contrast imaging through wavefront **stability**
- High-contrast imaging through wavefront **control**
- High-contrast imaging through wavefront **tolerance**
- Solution consists of a combination of all three

Value chain to develop core technology

- **Technology Innovation Research - 망원경 핵심기술 개발연구**
 - Phase 1: 개념 및 실험실 연구 (tradeoff study) - 5천만원/년
 - Phase 2: 실증연구 (Decision making) - 1.5억원/년 (Phase 1 x 3)
 - ex) 자외선 광학부품개발기술(설계, 연마, 측정, 코팅, 환경시험 등), 전개기술, 동일위상기술, 제어기술, 광학시스템통합환경시험 구축 및 시험기술 등
- **Philosophy**
 - 국가 경쟁력 확보: 복수 개발체계 확립 (Secure dual vendors)

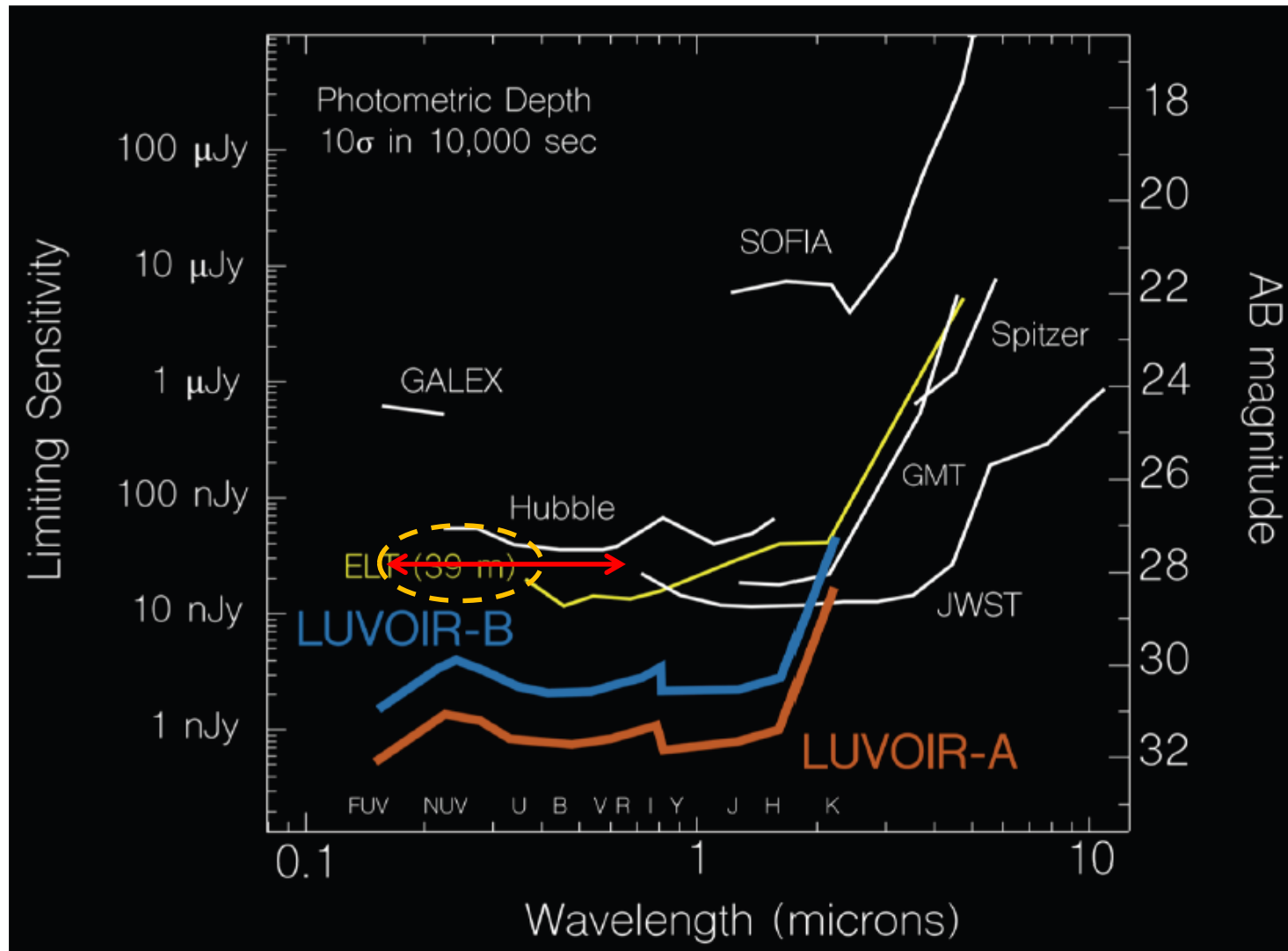
국외 대형우주망원경 사례

Large UV/Optical/IR Surveyor (LUVOIR)

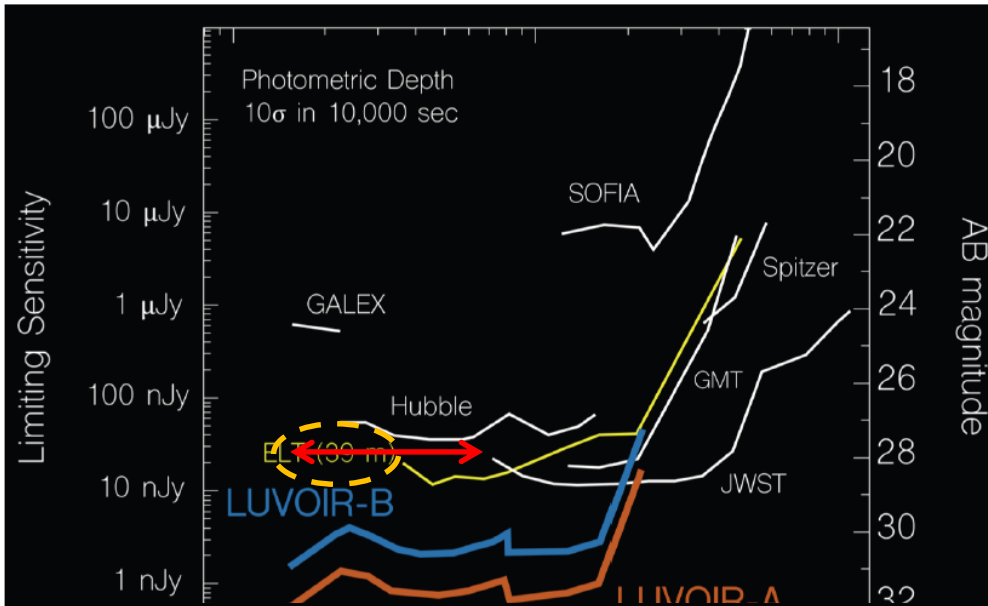


Ref.) <https://asd.gsfc.nasa.gov/luvor/>

Large UV/Optical/IR Surveyor (LUVOIR)



ref) www.nasa.gov, LUVOIR final report



ref) www.nasa.gov, LUVOIR final report

CANDIDATE INSTRUMENTS STUDIED

ECLIPS		HDI		LUMOS		POLLUX	
Coronagraph with imaging and imaging spectroscopy		Wide field imager with simultaneous UV/Vis and NIR coverage		UV/Vis multi-object spectrograph and FUV imager		Point-source UV spectropolarimeter (European study for LUVOIR-A only)	
Bandpass	200–2000 nm	Bandpass	200–2500 nm	Bandpass	100–1000 nm	Bandpass	100–400 nm
Contrast	1×10^{-10}	FoV	3' × 2'	MOS FoV	2' × 2'	R ($\lambda/\Delta\lambda$)	120,000
IWA	3.5 λ/D	67 science filters + grism		Apertures	840 × 420	Circular + linear polarization	
OWA	64 λ/D	Nyquist sampled		R ($\lambda/\Delta\lambda$)	500–50,000		
R ($\lambda/\Delta\lambda$)	Vis: 140 NIR: 70, 200	High-precision astrometry					

LUVOIR

OBSERVATORY CHARACTERISTICS

Community-driven observing program

Serviceable and upgradable modular design

Sun-Earth L2 orbit

Late 2030s launch date

5-year prime mission; 10 yrs. consumables;
25-year lifetime goal for non-serviceable
components

Diffraction limited at 500 nm; 270 K
telescope operating temp.

Field-of-regard: Sun-Telescope-Target
angles > 45 degrees (3π steradians)

Tracking speed: 60 mas/sec (2x JWST)

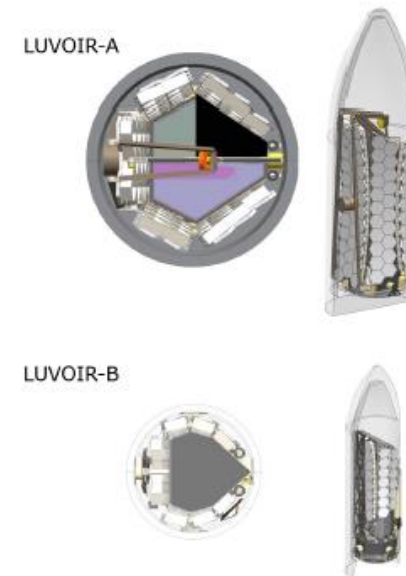
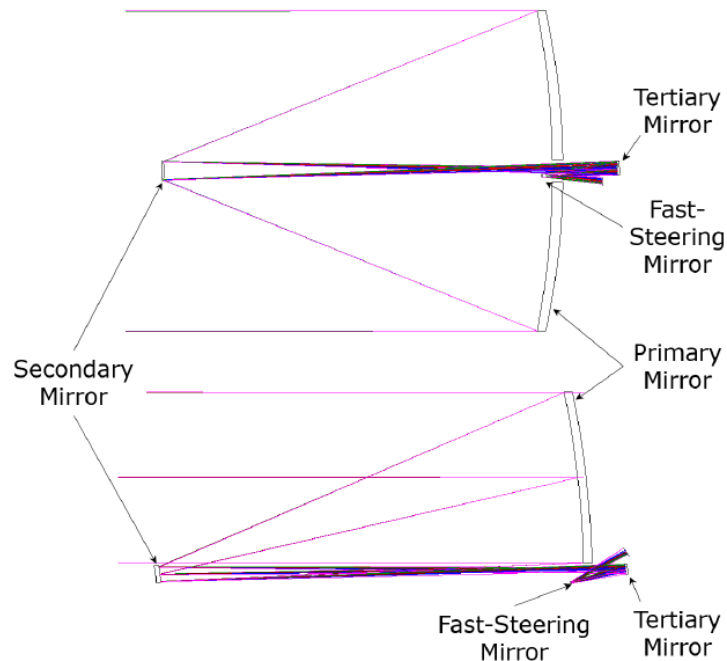
Observatory Characteristics - STACK

- Community-driven observing program
- Serviceable and upgradable modular design
- L2 orbit(?) → Q to Community
- **Early** 2030s launch date → Q to Gov.
- 5-year prime mission; 10 yrs. Consumables;
25-year lifetime goal for non-serviceable Components
- Diffraction limited at 500 nm; 270K(?) telescope
Operating temp.
- Field-of-regards; Sun-Telescope-Target
Angles > 45 degrees (?) → Q to Community
- Tracking speed: 60 mas/sec → Q to Community

[ref\) www.nasa.gov](http://www.nasa.gov), LUVOIR final report

Mission Concept study team

1. Science and Technology Definition Team
2. Study Office & Engineering Team
3. Community Working Group Members
 - Cosmic Origins, Exoplanets, Solar System, **Technology**



[ref\) www.nasa.gov](http://www.nasa.gov), LUVOIR final report

Risk identification

1. Integration and test facilities
2. Technology development
3. Verification and validation approach
4. Contamination control
5. Launch vehicle
6. Technical margin philosophy (for mass and power)

(ref) www.nasa.gov, LUVOIR final report

Risk identification - STACK

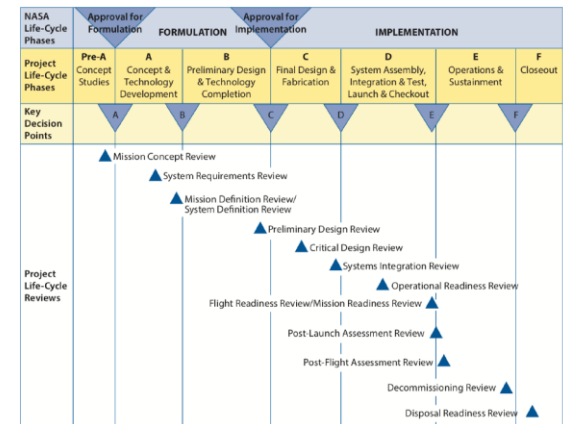
1. **Project Management and Systems Engineering**
2. Integration and test facilities – KASI, KARI facility (TBC)
3. Technology development – telescope, instruments and so on.
4. Verification and validation approach
5. Contamination control
6. Launch vehicle
7. Technical margin philosophy (for mass and power)

■ 국내 기술개발 역량 탐색

- 망원경 기술개발모임을 통한 망원경기술 분야별 산학연 유관기관 탐색 진행 중
(참여희망기관 연락: 천문연 한정열(jhan@kasi.re.kr), 042-865-2147)
- 국내 역량결집을 통한 우주망원경 기획 참여

■ 국외 대형우주망원경 사례를 참고한 개발계획수립 예정

- Pre-A: Concept Studies
- A: Concept & Technology Development
- B: Preliminary Design & Technology Completion
- C: Final Design & Fabrication
- D: System Assembly, Integration & Test, Delivery



ref) www.nasa.gov, LUVOR final report