NATIONAL RADIO ASTRONOMY OBSERVATORY

ngVLA Antenna Concept

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ngvla

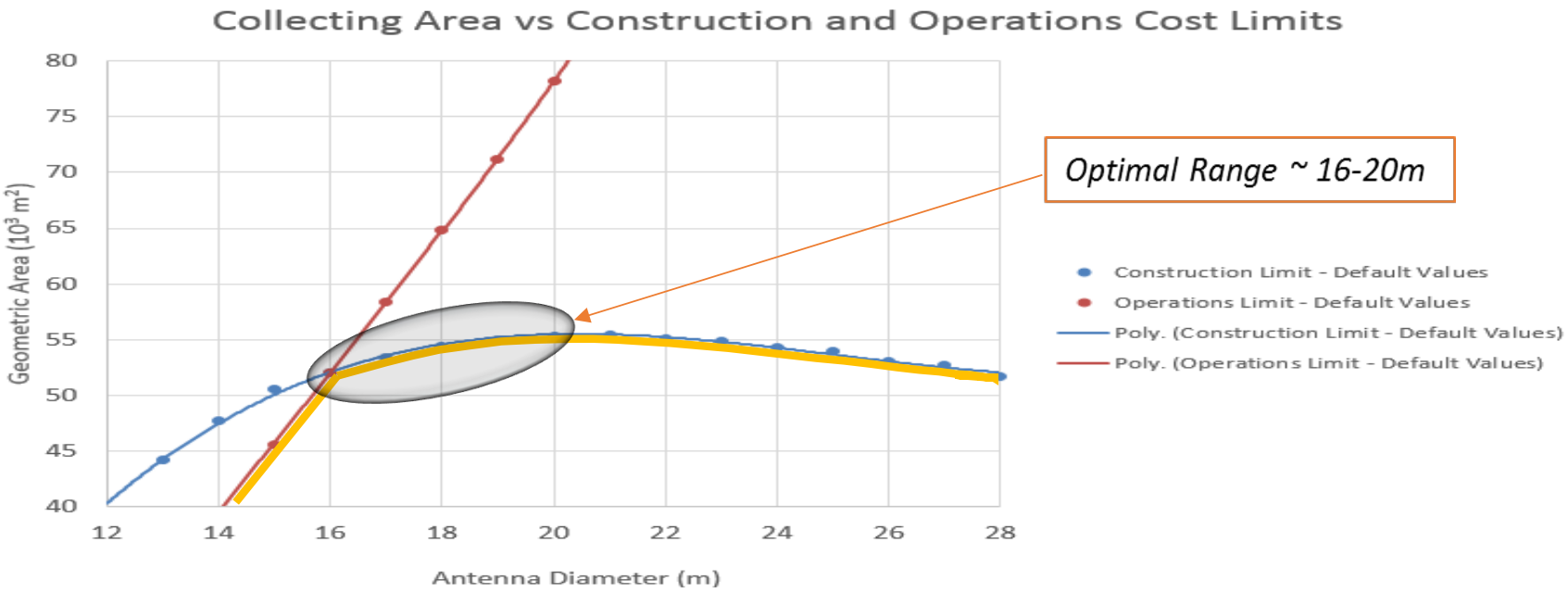
Next Generation Very Large Array

Topics

- Design Considerations
  - Antenna Size
  - Antenna Configuration
  - Optical Concept
- Specifications
- Technical Risk
- Design Studies

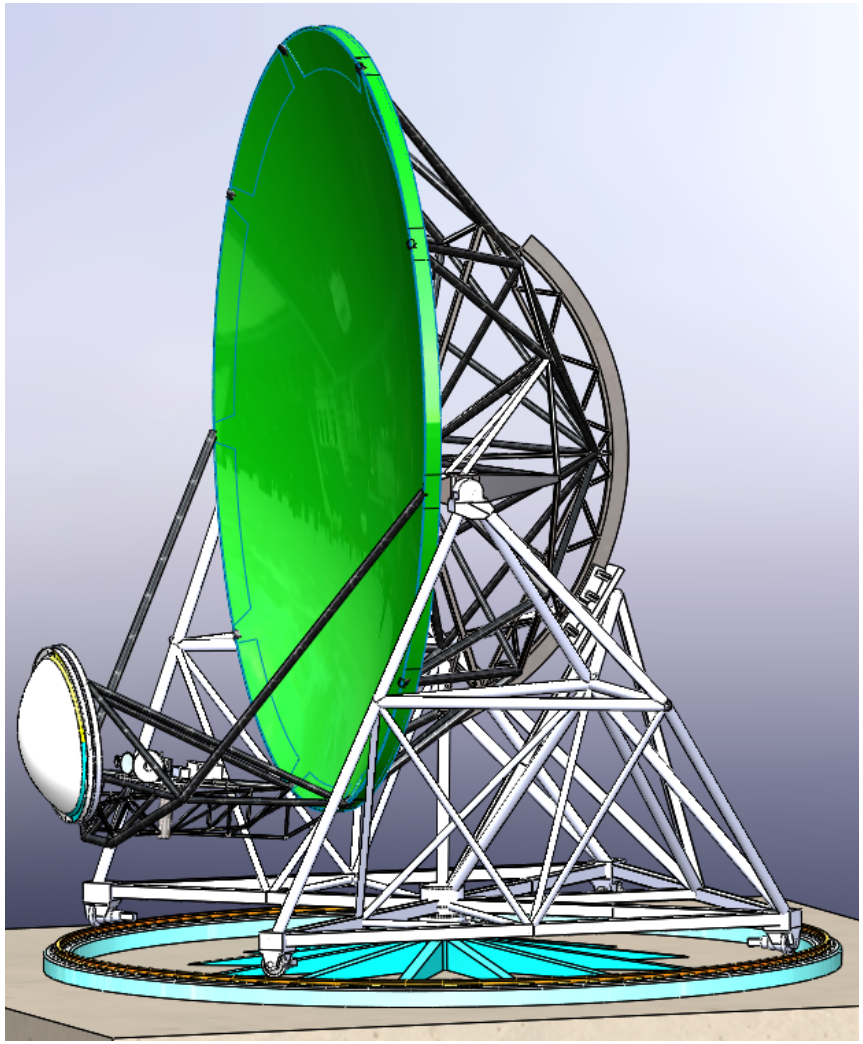
Design Considerations:
Antenna Size

- 18 meter aperture size for baseline design
  - Good balance of sensitivity and survey speed
  - Meets construction and operations cost targets
  - Largest size that may be achievable w/ single piece rim supported composite reflector



Design Consideration:
Antenna Configuration

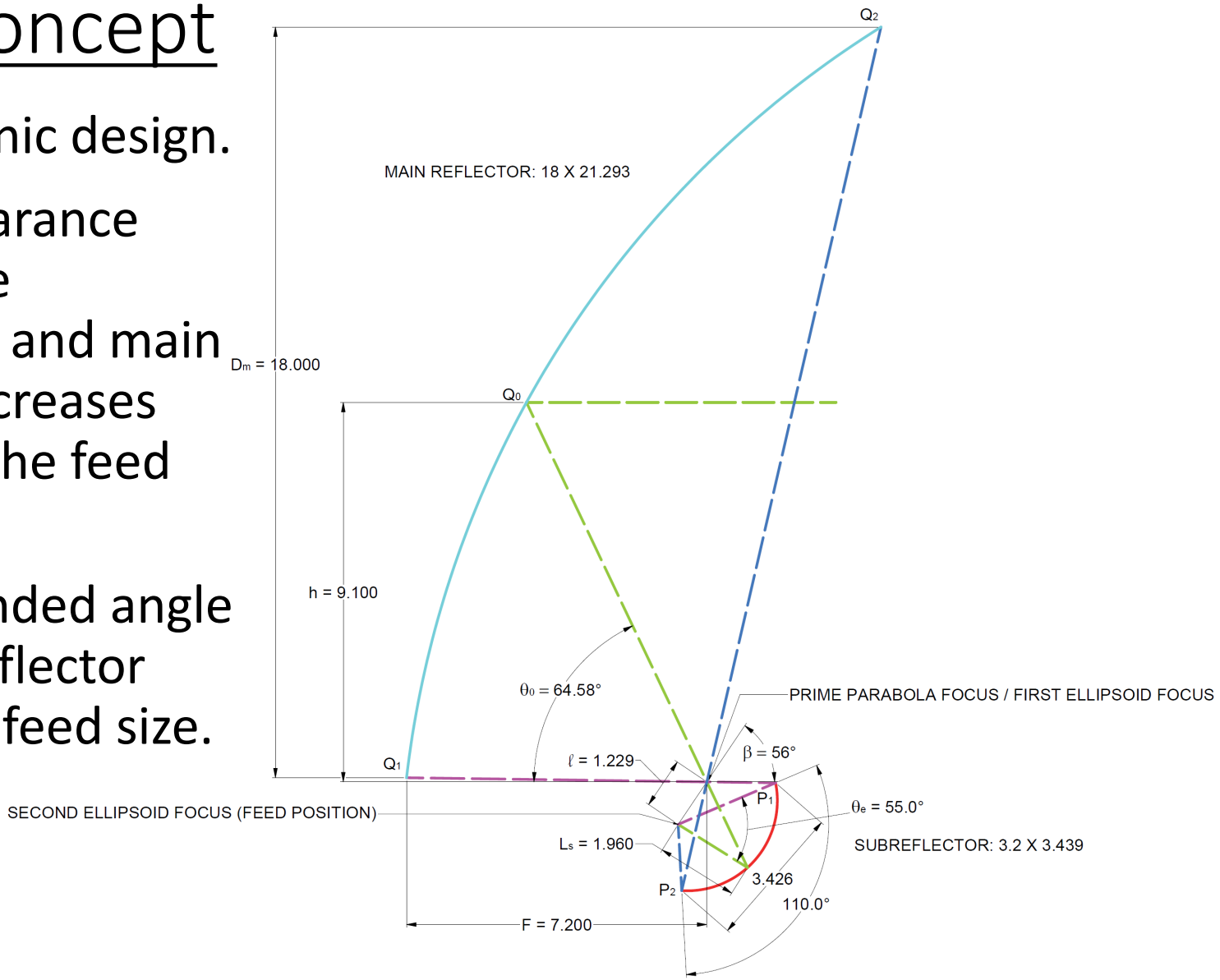
- Offset Gregorian geometry w/ unblocked aperture
  - Minimizes scattering, spillover and sidelobe pickup
  - Wide secondary angle of illumination
    - Leads to low cost compact feed designs
    - Allow use of just two common cryogenic dewars for reduced operations and maintenance costs
- Feed Arm Low configuration
  - Better spillover performance
  - Simpler access for maintenance
  - Minimizes shadowing in array core



Drawing courtesy NRC Canada

Design Consideration:
Optical Concept

- Standard conic design.
- Minimal clearance between the subreflector and main aperture increases stiffness of the feed arm
- Wide subtended angle of the subreflector reduces the feed size.



Preliminary Technical Specs

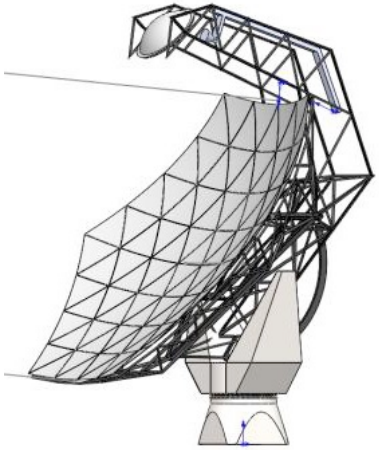
Parameter	Summary of Requirement	Reference Reqs.
Frequency Range	1.2-116 GHz	ANT0101, ANT0102, ANT0103
Diameter	18m	ANT0202
Number of Antennas	214	ANT0401
Surface Accuracy	**Precision Operating Conditions** 160 µm RMS (λ/16 @ 116 GHz), primary and subreflector combined. **Normal Operating Conditions** 300 µm RMS, primary and subreflector combined.	ANT0501, ANT0502
Pointing Accuracy	**Precision Operating Conditions:** Absolute pointing: 18 arc sec RMS Referenced pointing: 3 arc sec RMS (4 deg angle, 15 min time) **Normal Operating Conditions:** Absolute pointing: 35 arc sec RMS Referenced pointing: 5 arc sec RMS (4 deg angle, 15 min time)	ANT0611, ANT0612, ANT0621, ANT0622
Tracking Range	Azimuth: ± 270 deg Elevation: 12 deg to 88 deg	ANT0801, ANT0802
Movement Rate	Slew: Azimuth 90 deg/min, Elevation 45 deg/min. Tracking: Azimuth 7.5 deg/min, Elevation 3.5 deg/min.	ANT0901, ANT0902, ANT0906
Antenna Geometry	Offset Gregorian, satisfying Mizuguch-Dragone polarization condition, with focal point on bottom.	ANT0201, ANT0206, ANT0211
Environmental conditions	**Survival Conditions at Stow Position:** Wind ≤ 50 m/s, temperature ≥ -40 C, 2.5 cm radial ice, 25 cm snow in dish. 2.0 cm diameter hailstones **Precision Operating Conditions:** Night time only, wind ≤ 7 m/s, temperature ≥ -15 C, no precipitation. **Normal Operating Conditions:** Day and night, wind ≤ 10 m/s, temperature ≥ -15 C, no precipitation.	ANT1411 through ANT1446

Fully documented in Preliminary Antenna Technical Specification: Project Document No. 020.25.00.00.00-0001-SPE Release "A".

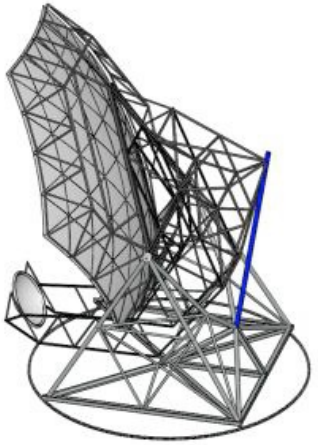
Technical Risk:
Challenging 3” Reference Pointing Requirement

- Leads to the need for a:
  - Very stiff structure
  - Substantial Antenna Foundation
  - Advanced drive system
- Solution is application of new and novel technologies
  - Composite structural members in feed arm & backup structure
    - Reduces mass
    - Increases structural stiffness
  - Composite reflectors
  - Wheel & track type mount using COTS crane rail components

Current planning leads to Meerkat style pedestal antenna w/ feed low configuration & challenging mechanical design



Pedestal design leads to feed up configuration which is more difficult to maintain



Wheel & Track design w/ feed down configuration is more compact and easier to maintain

Drawings courtesy M. Fleming, R. Schultz, D. Enterline

Design Studies

- The ngVLA project is currently in requirements definition and conceptual development stage
- Proceeding beyond this requires endorsement of:
  - Astro 2020 Decadal Survey
  - NSF Division of Astronomical Sciences Directorate
- Project merit will be judged on technical readiness & cost realism
- At ~50% of the project cost, a clear understanding of the antenna design and costs are critical to this process
- Several design studies are underway to address these areas

Design Studies

- General Dynamics, Richardson TX
  - Contract under negotiation for a costed reference design to meet project specifications
    - Explores cost effective concepts that meet project requirements
    - Provides a reference design w/ known technical risk and cost
    - Provides sufficient detail to reliably estimate cost & performance
    - Not sufficient detail to allow construction of a prototype
  - NRAO expectations:
    - Design can be manufactured in volume and delivered affordably
    - Will not push technical boundaries
  - Also focused on:
    - Reduced maintenance burden
    - Reduced total life cycle cost

Design Studies

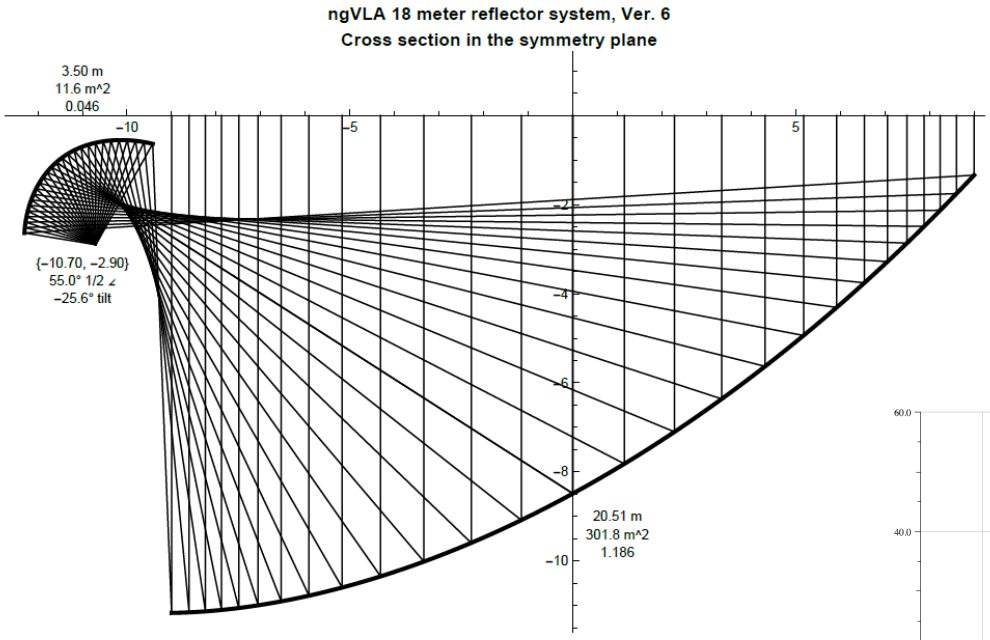
- National Research Council of Canada – 18m study
  - Produce an alternate concept for an 18m design emphasizing composite reflectors, likely single-piece reflectors.
  - Intended to be complementary to the General Dynamics reference design which:
    - Is inherently lower risk
    - May avoid using emerging technologies and techniques
  - NRC's work is:
    - Higher risk for higher reward
    - Ensuring that novel and viable concepts continue development through to the conceptual design down select

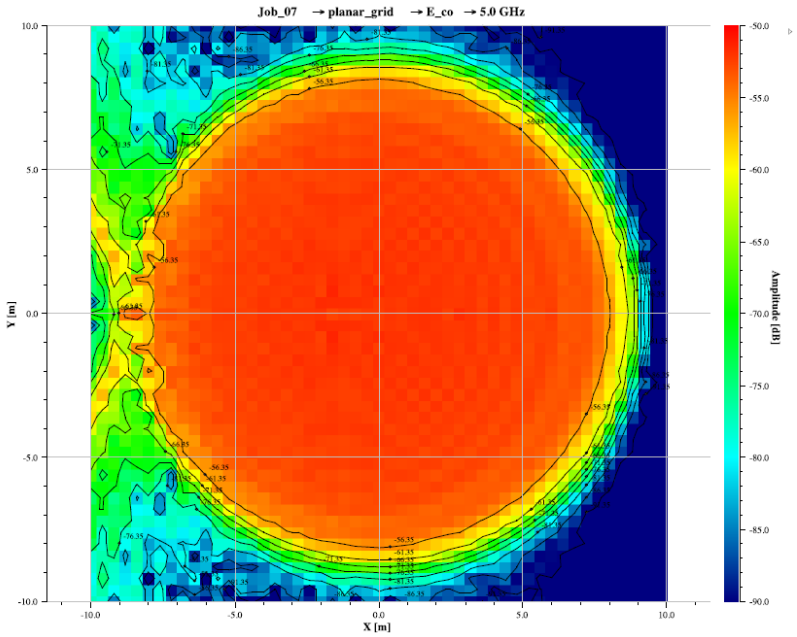
Design Studies

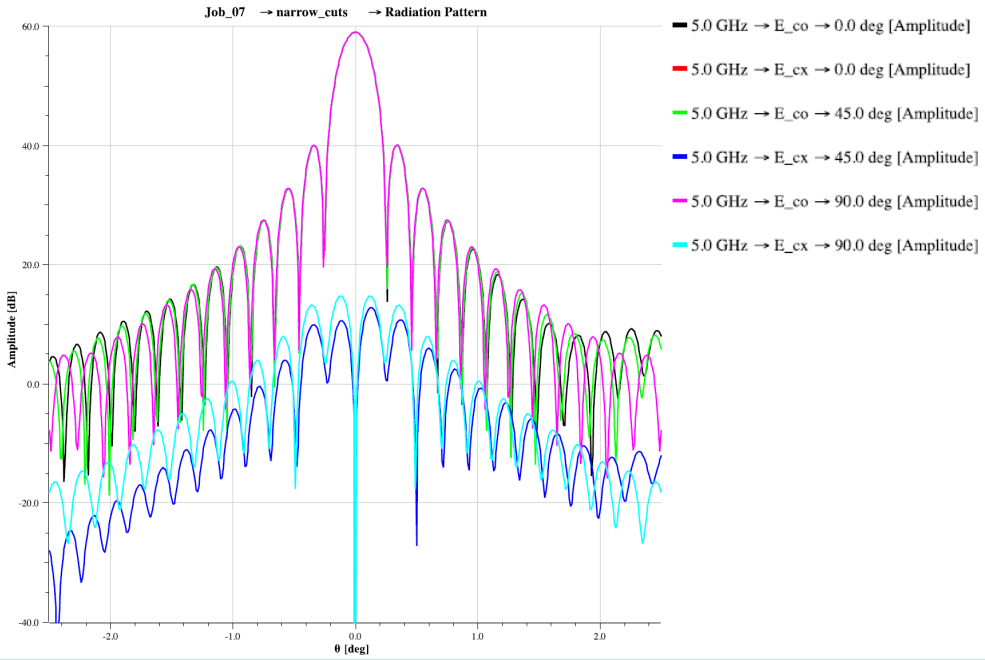
- National Research Council of Canada – Optics study
  - Study of optics for the 18m offset Gregorian antenna
  - Objectives:
    - Define “optical prescription” of ngVLA Reference Design
    - Provide EM analysis of reference design optics
  - Design will employ shaped reflectors to
    - Optimize forward gain
    - Reduce spillover temperature w/ single pixel feeds
  - This optical design will be used by both General Dynamics and NRC Canada for their respective antenna design studies

Design Studies

- NRC – Optics study







- Shaped reflectors for optimal sensitivity with single pixel feeds
  - 89 % illumination efficiency with idealized Gaussian feed
  - -20 dB first sidelobe

Images courtesy Lynn Baker & NRC

References

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ngvla.nrao.edu

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