Opportunities for Better Gas Management

ACARP Gas and Outburst Workshop

Mackay, 16th September 2005

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Opportunities for Better Gas Management

- Gas Management Milestones 1900 to 2000
- Current Gas Management Practices - 2005
  - In-seam drainage economics
- Future Opportunities – 2010?
  - Parametric study of differing drainage strategies

Australian Gas Management – 1900 to 2000

- 1925 Metropolitan Colliery
  - Following fatal outburst, 30 m in-seam holes ahead of face
- 1930+ Balmain Colliery
  - Gas utilisation drainage via vertical wells to 1386m (post closure)
- 1954 State Mine
  - Following fatal outburst, 80 m in-seam holes ahead of face, vacuum on drainage holes, quantitative gas desorption methods (*Biggam, Robinson & Ham*)
- Late 1970's to early 1980's
  - Numerous significant studies into gas reservoir character and drainage efficiencies at Leichhardt, Bowen #2, Collinsville *(Gray, Williams)*
  - Initial long-holing drill trials at Collinsville

Australian Gas Management – 1900 to 2000

- Late1970's West Cliff Colliery
  - Gas drainage feasibility studies for outburst control (*Lama, Marshal, Griffith)*
- 1980 West Cliff Colliery and 1982 Appin Colliery
  - Surface gas drainage vacuum plants, first mine-wide pre-drainage and post-drainage systems
  - Cross-measure post-drainage of Balgownie and Wongawilli seams
- 1982 West Cliff Colliery
  - In-seam hole driven to 471 m with Acker "Big John" rig *(ACIRL)*
- Late 1980's
  - Use of down-hole motors, down-hole surveying, in-seam directional drilling to 1000 m
  - In-house drilling teams established, emerging U/G drilling contractors

Australian Gas Management – 1900 to 2000

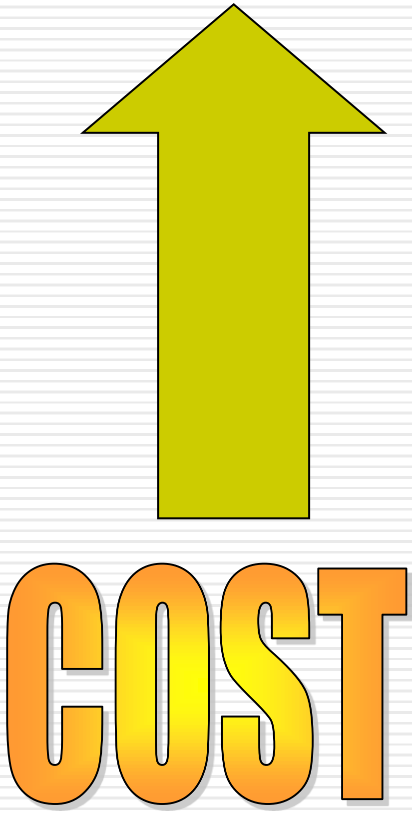
- 1990's
  - Industry-wide adoption of fully surveyed, cross-panel pre-drainage holes using DHM technology at 300 m to 450 m (but up to 1500 m)
  - "Maturation" of in-seam drill contracting business
- 1992 Central Colliery
  - Surface vacuum plant for in-seam drainage
  - Mobile goaf drainage plant using liquid ring pump, cased to below tertiary
- 1997 Dartbrook Colliery
  - Surface vacuum plant for in-seam drainage (1996)
  - Mobile CO_2 goaf drainage plants and slider casing to goaf

Current Gas Management - 2005

- 2000's Moura Seam Gas and Grasstree Colliery
  - Trials of tight radius drilling technologies
- 2001-2004
  - Surface to in-seam medium radius drilling implemented at Moranbah Gas Project by CH4 Pty Ltd and Mitchell Drilling
  - Emerging SIS drilling contractors
- 2005
  - MRD pre-drainage adopted by Oaky Creek, Grasstree, Newlands, Moranbah North, West Cliff and Beltana
- So in summary…..

Current Gas Management - 2005

- Surface to In-seam Pre-Drainage (SIS)
- In-seam Pre-Drainage (UIS)
- In-seam Post-Drainage
- Surface Post-Drainage
- Mains Ventilation Dilution



Current Gas Management - 2005

- ***Mains Ventilation Dilution***

  Pros

  - Most cost effective (Fractional cents per tonne mined impost)
  - Mature technology – engineered solution, universally applicable
  - Surface based, divorced from mining operations

  Cons

  - Suited to "baseload" emissions, not acute emission sources
  - Not readily scalable (beyond additional fans, VVVF drives)
  - Ultimately limited by rising pressure differentials, airway velocities, propensity to spontaneous combustion hazards
  - Drained gas in highly dilute form – not easily utilised

Current Gas Management - 2005

- ***Surface Post Drainage***

  Pros

  - Cost effective (Cents per tonne mined impost)
  - Potential for useable seam gas purities (>40% CH_4)
  - Surface based (potentially self-powered)
  - Centralised or mobile and modular, as required

  Cons

  - Potential for geotechnical constraints and application limits
  - Not divorced from operations, additional hazards to control
  - Suited to “baseload” emissions, not acute emission sources

Current Gas Management - 2005

- ***In-seam Pre-Drainage (UIS) and Post-Drainage***

  Pros

  - Potential for high seam gas purities
  - Mature technology – bonus of exploration data
  - Potential for optimised permeability and drainage performance
  - Can be scheduled to short lead-times (sometimes <100 days)

  Cons

  - High operating costs (Dollars per tonne mined impost)
  - Drilling schedules and logistics "chained" to development, but also significant impost to mining operations
  - Potential for drilling induced hazards to operations
    - Intersection, location and treatment of high flow / blocked boreholes
    - "Stub" emissions / excessive borehole flows
    - Loss and recovery of equipment
    - Spontaneous combustion potential / Water in-rush
  - Borehole damage from drilling near desorption pressure thresholds

Current Gas Management - 2005

- ***Surface to In-seam Pre-Drainage (SIS)***

  Pros

  - Potential for high seam gas purities
  - Potential for optimised permeability and drainage performance
  - Divorced from mining operations
  - Potential for reduction in drainage costs where lead-time permits
  - Drilling at reservoir gas pressures, limited damage to boreholes (potential for under-balance drilling)
  - Increased mining certainty from drill control, exploration data

  Cons

  - High, up-front costs (Dollars per tonne mined impost)
  - New technology, new equipment, new management practices
  - The KISS principle
  - Potential for drilling induced hazards to operations
  - Long lead-times required for economic feasibility (+1000 days)
  - May not be applicable given surface constraints, adverse reservoir conditions

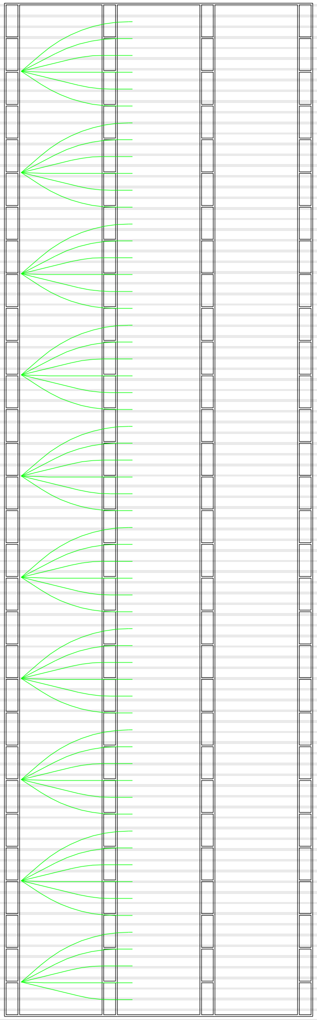
Current Gas Management - 2005

- ***SIS Pre-Drainage versus UIS Pre-Drainage***
  - SIS pros outweigh cons
  - SIS requires long lead times
  - UIS may induce poor drilling / drainage conditions
  - UIS constrained in logistics, scheduling and application by mining schedule
  - SIS outcomes *potentially* superior given
    - Adoption of the new SIS technologies & management practices
    - Engineered assessment of gas reservoir behaviour
    - Designed “draw-down” strategies
    - Active fitting & re-projection of gas reservoir behaviour during drainage

Critical factors – common to both approaches

- Economics
- Potential for drilling induced hazards to operations

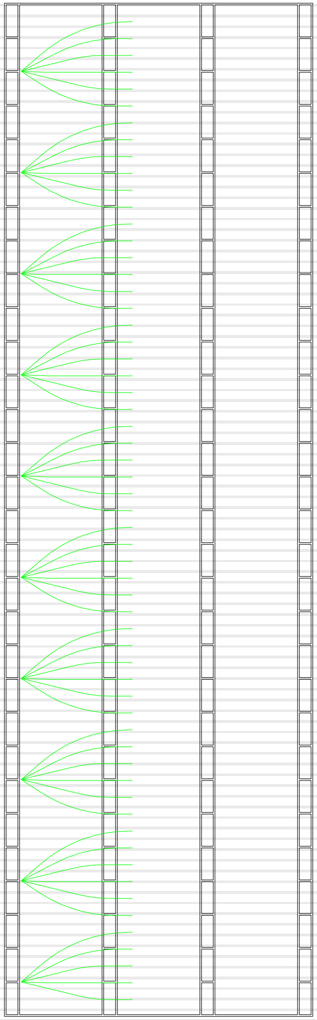
Current Economics - UIS Drainage



- 3 km LW, 320 m deep, 250 m face, 40 m pillars
- In-seam development pre-drainage via 10 stubs
- 6 hole fan pattern, 50 m spacing (300 days)
- Holes 330-390 m long (360-430 m with branches)
- Drilling cost per stub (inc conduit, standpipes & cores & delays) = $214,160 (Aus$ 2005)
  = $95 / m
- Incl. of stub driveage = $115 / m
- Incl. of stub preparation = $125 / m
- Incl. of equipment hire = $135 / m
- Incl. of stub re-support = $145 / m
- Incl. of stub gas riser = $180 / m

Total direct cost 10 stubs, 1 LW = $4.56 Million

Current Economics - UIS Drainage

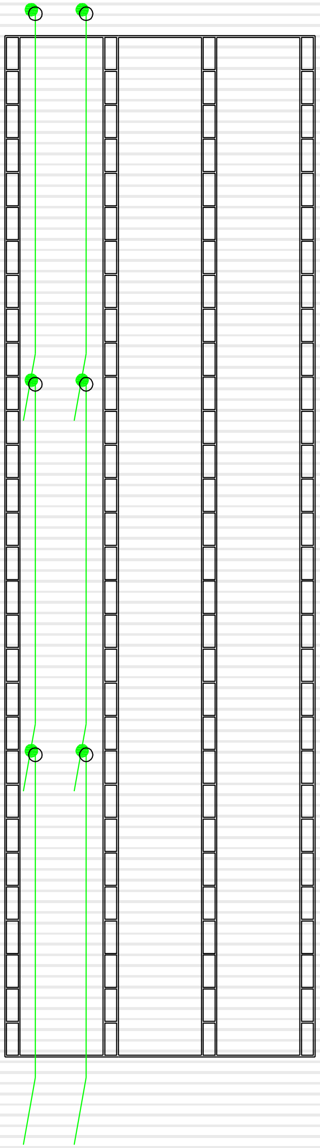


Total direct cost 10 stubs, 1 LW = $4.56 Million

Indirect costs not included :-

- **Lost development from drilling induced gas contamination of headings**
- **Losses to development caused by negotiation of in-seam boreholes**
- **Loss of equipment and delays induced by poor drilling conditions (at gas desorption pressures)**
- **Internal cost <= $500,000 per annum in dedicated gas management staff and drainage officers**

Current Economics - SIS Drainage



- 3 km LW, 320 m deep, 250 m face, 40 m pillars
- 6 SIS holes on 150 m spacing
- Full panel drainage on 2000 day term
- 1000 m laterals in-seam, total ~ 1400 m
- Raw drilling cost ~ $100 / m
- Cost per lateral (inc casing to seam & in-seam casing) = $260,000 (Aus$ 2005) = $260 / m
- Incl. of production well = $347 / m
- Incl. of pump, manual monitor & automated control equip = $417 / m

Total direct cost 6 holes, 1 LW = $2.50 Million

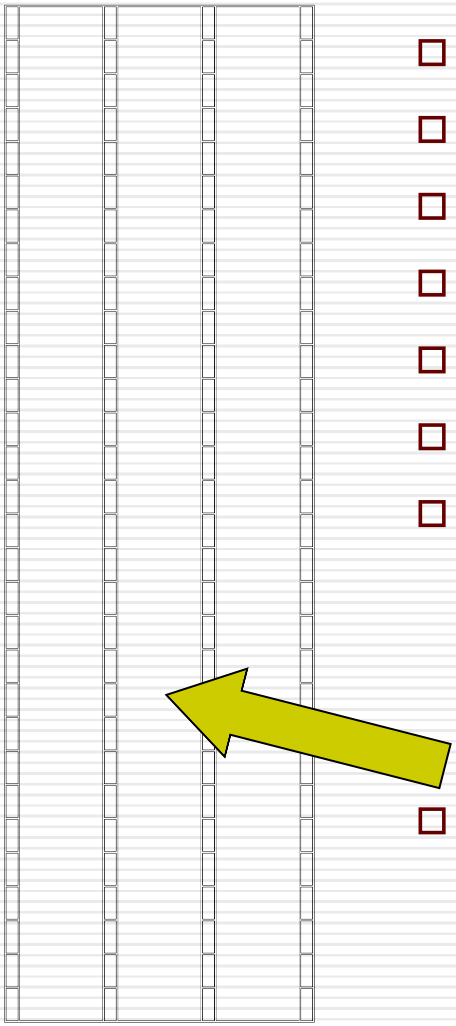
Cost inc manual monitor for term = $4.60 Million

Cost inc remote monitor for term = $4.80 Million

Future Opportunities – Gas Management

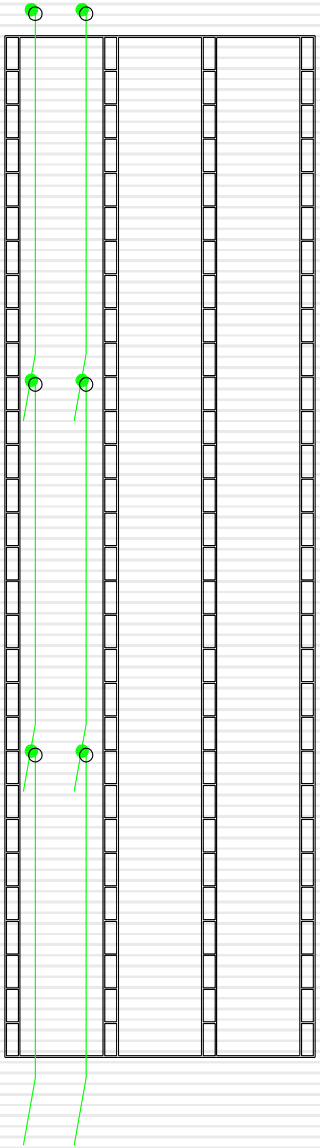
- ***SIS Pre-Drainage***
  - Costs have actually risen in last 10 years - $70 / m to $100 / m
  - SIS contractors dealing with
    - Chronic manning shortages, high labour costs
    - Higher steel costs
    - Higher fuel costs
    - Higher equipment costs
  - Improved economics and drainage outcomes will come from "smarter":-
    - Reservoir mapping
    - Drainage design
    - Drill execution
    - Hole completion
    - Flow commissioning
    - Drainage operations

Future Opportunities – SIS Parametric Study



- 3 km LW, 320 m deep, 250 m face, 40 m pillars
- Seam thickness 5 m, Seam ash 18.4%
- Seam virgin gas content 10 m^3/t CH_4
- Target residual gas content 3.5 m^3/t CH_4
- Gas saturation 89%
- Permeability along major cleat 10 mD
- Permeability across major cleat 30 mD
- Main dip 3°

Future Opportunities – SIS Parametric Study #1

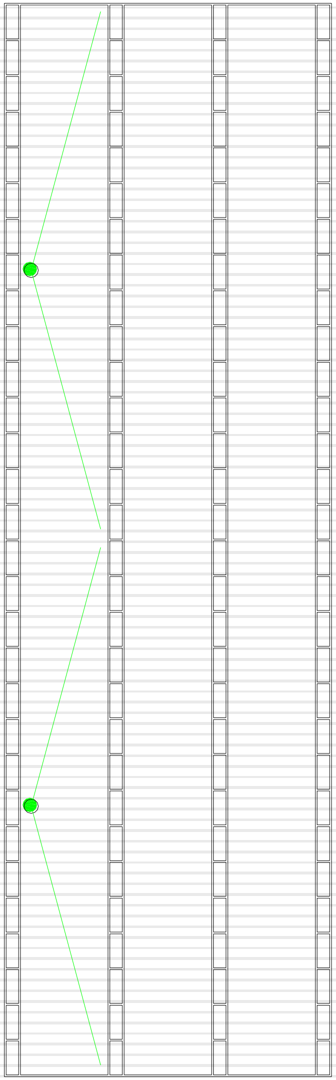


- 6 SIS holes on 150 m spacing
- 1000 m laterals in-seam, total ~ 1400 m
- 6000 m laterals per longwall
- 6 production wells per longwall
- Holes aligned with gateroads (along major cleat)
- Minimal gateroad intersection of laterals
- Effective permeability 10 mD
- Constraints on spacing / drainage optimisation

Parametric Study #1

- Full LW panel drainage on 2000 day term
- Total cost inc remote monitor for term
  = $4.80 Million per LW

Future Opportunities – SIS Parametric Study #2

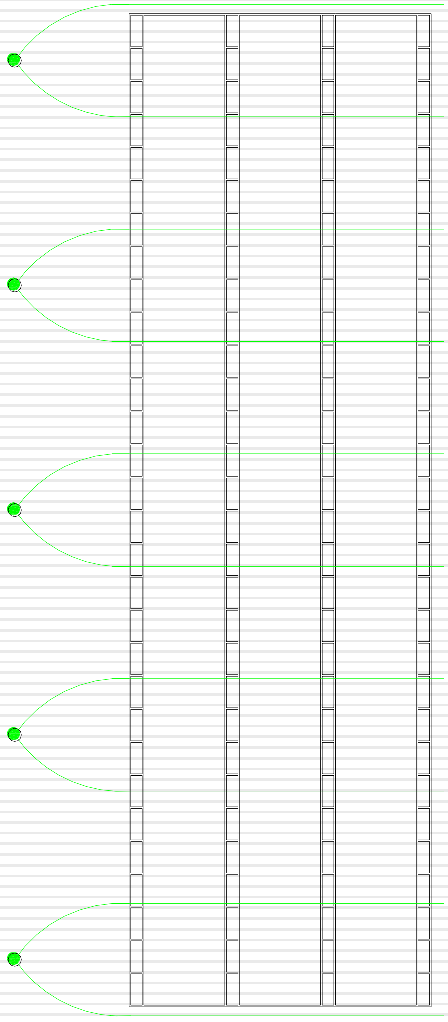


- 4 SIS holes on 350 m spacing
- 750 m laterals in-seam
- 3000 m laterals per longwall
- 2 production wells per longwall
- Holes aligned with gateroads (along major cleat)
- Minimal gateroad intersection of laterals
- Effective permeability ~10 mD
- Constraints on spacing / drainage optimisation

Parametric Study #2

- Full LW panel drainage on 5500 day term
- Total cost inc remote monitor for term
  = $7.20 Million per LW

Future Opportunities – SIS Parametric Study #3

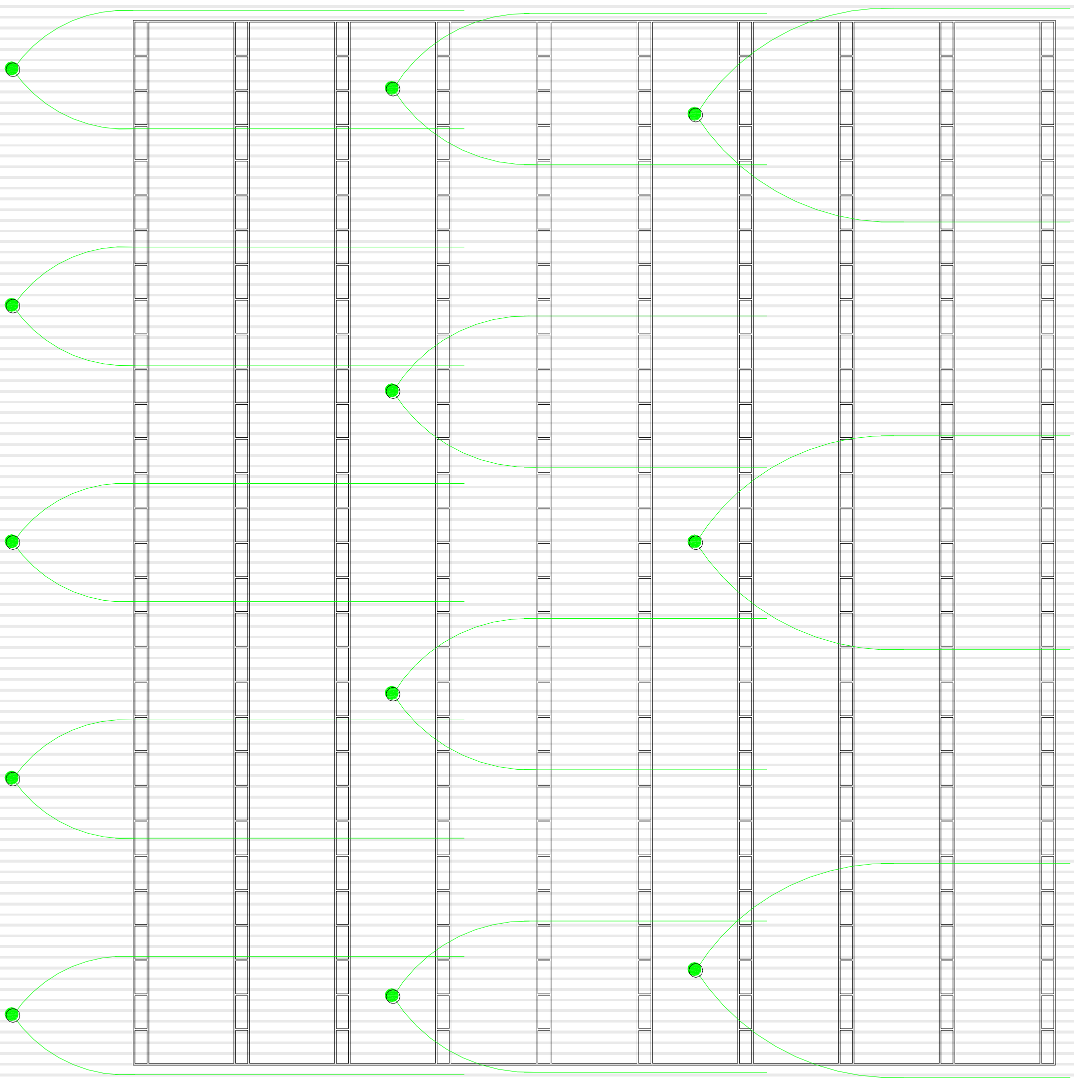


- **10 SIS holes on 340 m spacing**
- **1200 m laterals in-seam**
- **4000 m laterals per longwall**
- **<2 production wells per longwall**
- **Holes aligned across major cleat**
- **Maximum gateroad intersection of laterals**
- **Effective permeability 30 mD**
- **Potential for optimising drill patterns**

Parametric Study #3

- **Three LW panels drained on 2000 day term**
- **Total cost inc remote monitor for term = $3.80 Million per LW**

Future Opportunities – SIS Drainage



- Increased hole spacing
- 1200 m laterals in-seam
- 2700 m laterals per LW
- <2 production wells per LW
- Holes aligned across major cleat
- Maximum gateroad intersection of laterals
- Total cost = $3.30 Million per LW

Opportunities for Better Gas Management

- ***SIS Pre-Drainage versus UIS Pre-Drainage***
  - Longer drainage terms required for SIS
  - Drainage outcomes might be achieved at comparable cost
  - Given
    - Engineered assessment of gas reservoir behaviour prior to drainage
    - Engineered design of "draw-down" and gas/water production strategies
    - Adoption of the best SIS technologies & management practices
    - Fitting & re-projection of gas reservoir behaviour, and adaptive operations during drainage

  There is potential for superior drainage outcomes with SIS

Challenge remains

- SIS holes must be oriented to maximise <u>not minimise</u> permeability
- Address potential for drilling induced hazards to operations
  - Re-working of holes with dedicated SIS rigs
  - Grouting of holes on completion
- Routine SIS drainage of adjacent seams to facilitate longwall extraction should be considered

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