

Low Costing Array Design Considerations for SKA

**Getting the Biggest Bang for our Buck...
OR
Seeing the Most Universe for our Euro!!**

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Overview



- Introduction to 2-PAD
- Equation
- Reducing the cost of high volume components
- Introduction to Engineering Design
- Example from SKA design work for 2-PAD
- Collaboration Issues

Introduction to 2-PAD



What?

2-PAD is one of JBCA's contribution to the SKADS programme
A small scale functional example of a fully digital
mid band (500MHz-1GHz) Phased Array Radio Telescope.

Where?

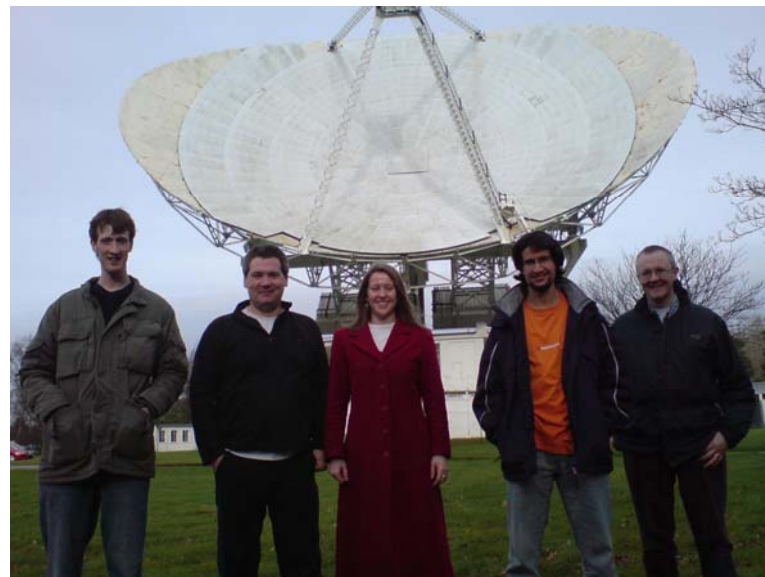
Initially located at JBO.

Who?

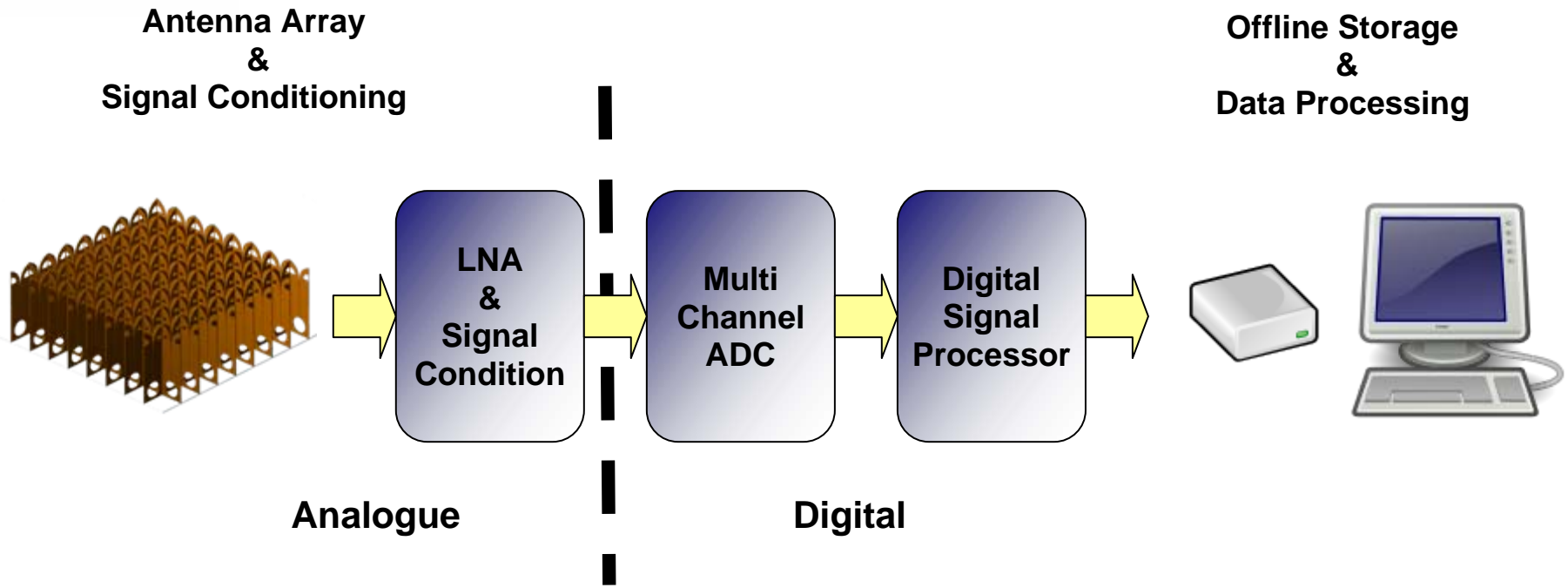
Design team based at JBO.

When?

Operational Mid 2009



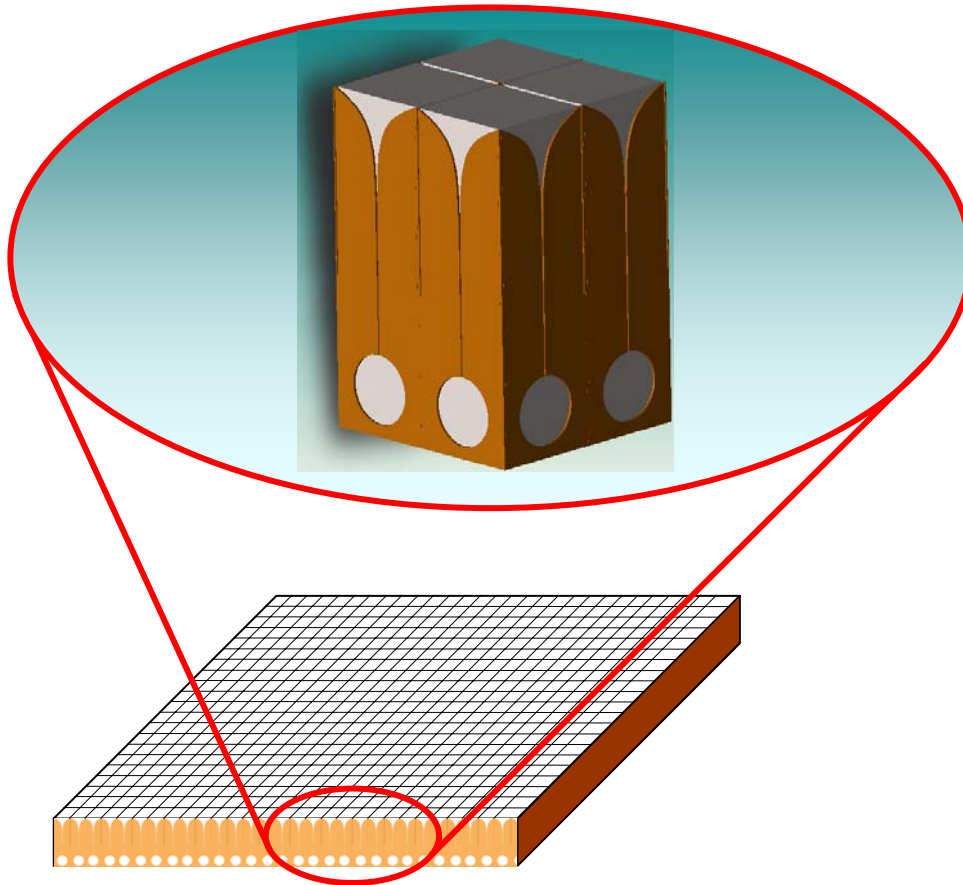
2-PAD Simplified System Overview



2-PAD is as fully 'Digital' as possible.

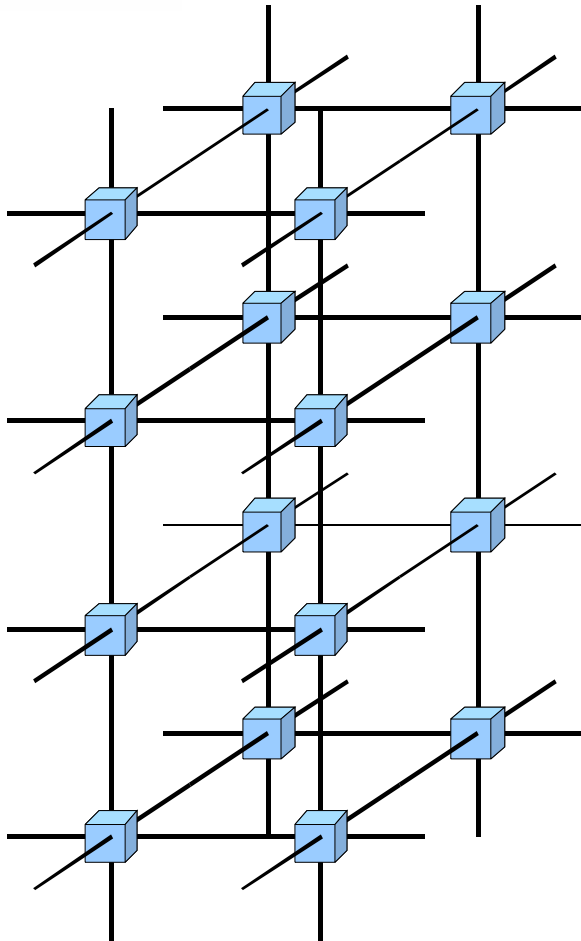
Pretty much everything downstream of the LNA is digitised

Antenna Array Tile Structure



- 2-PAD can be used to test a variety of antenna arrays
- Array can be dense or sparse
- How they are arranged has a big impact on the downstream processing requirements
- The University of Manchester Team are producing some antennas
- We are also buying a set of antennas from Astron.

Digital Processing Architecture



Large number of simple high performance processing elements.

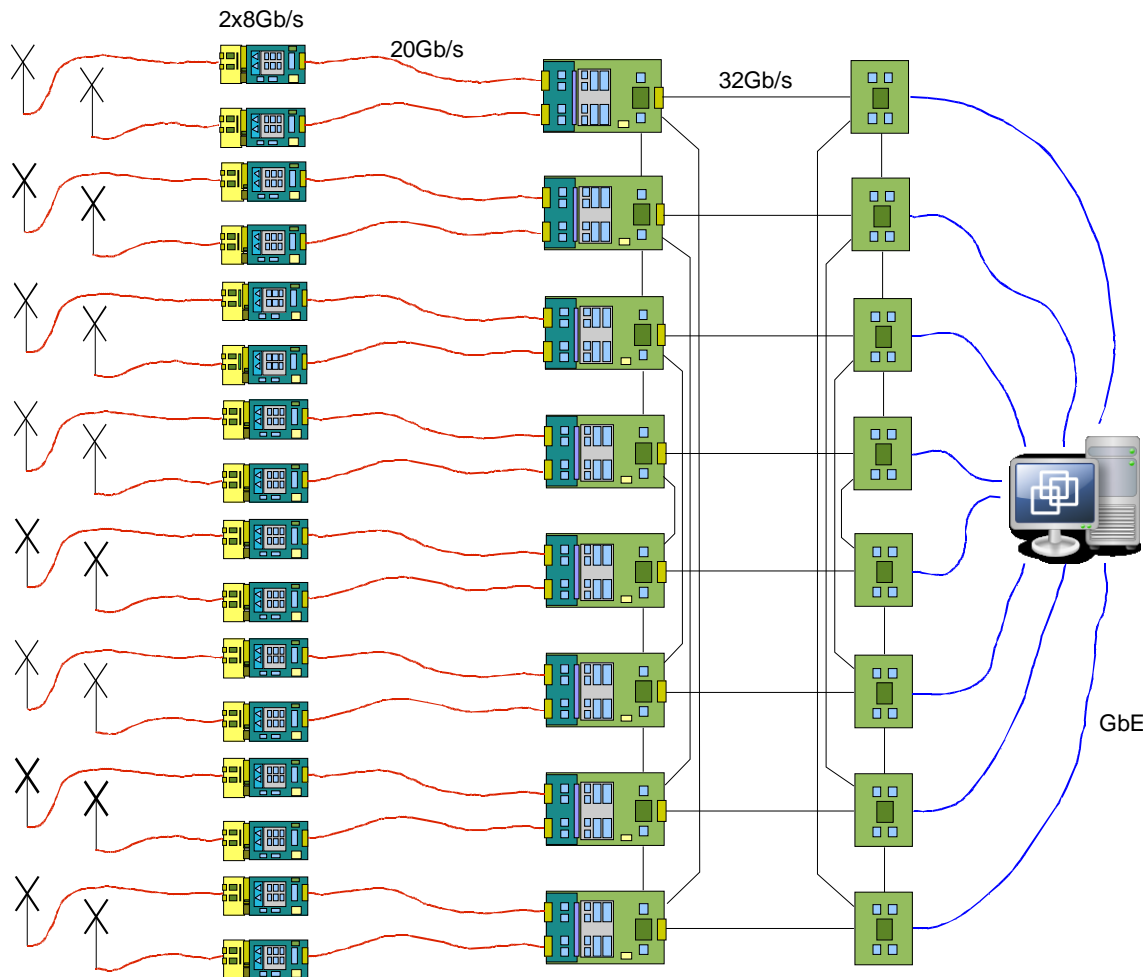
Connected together via very high bandwidth links.

Processing element means;

**On-chip – thread unit or similar functional unit.
Off-chip – multiple devices.**

Can be achieved using ASIC's, FPGA's or commercial processor technologies.

2-PAD Hardware Architecture



Data Acquisition

Digital Processing

GbE

Equation



$$E=Mc^2$$

The SKA is big. You just won't believe how vastly, hugely, mind- bogglingly big it is. I mean, you may think it's a long way down the road to the chemist's, but that's just peanuts to the SKA.

Misquote from The Hitchhiker's Guide to the Galaxy by Douglas Adams

23,040,000 Antennas

Reducing the Cost of High Volume Components



- Use castings, extrusions or other volume manufacturing processes to reduce machining
- Consult with manufacturing to determine and design for fixture-locating features on the component
- Avoid thin walls, thin webs, or similar features that will result in distortions due to manufacturing
- Avoid undercuts that will require special operations & tools
- Design around standard cutters, drill bit sizes or other tools
- Avoid small holes and threaded features as tool breakage and part scrap increases

Introduction to Engineering Design



- What is our **design specification**?
- **How long** have we got to design / manufacture our product?
- **How much money** have we got?
- Is this an **incremental or a step change** in product?
 - If it is a step change you **MUST** be tolerant of shortfalls against the specification
- Are we designing the whole system or are we working with partners?
- What design, engineering and manufacturing **tools** do we have?
- What **expertise** do we have access to
 - In our own teams?
 - In our collaboration partners?
 - In outside organisations?

KISS Principle for Low Cost Engineering Design



- Minimise the number of individual components
 - Every component costs money
 - Every component may have a defect
 - Every assembly operation has potential for error
- Minimise tolerancing
 - Close tolerancing increases the price of manufacture
 - Tolerances accumulate causing the assembly to require additional design
- Review all components within an assembly
 - Is it really needed?
 - Can it be combined with another component?
 - Can the function be performed in a simpler way?

Using Standard Components and Benchmarking



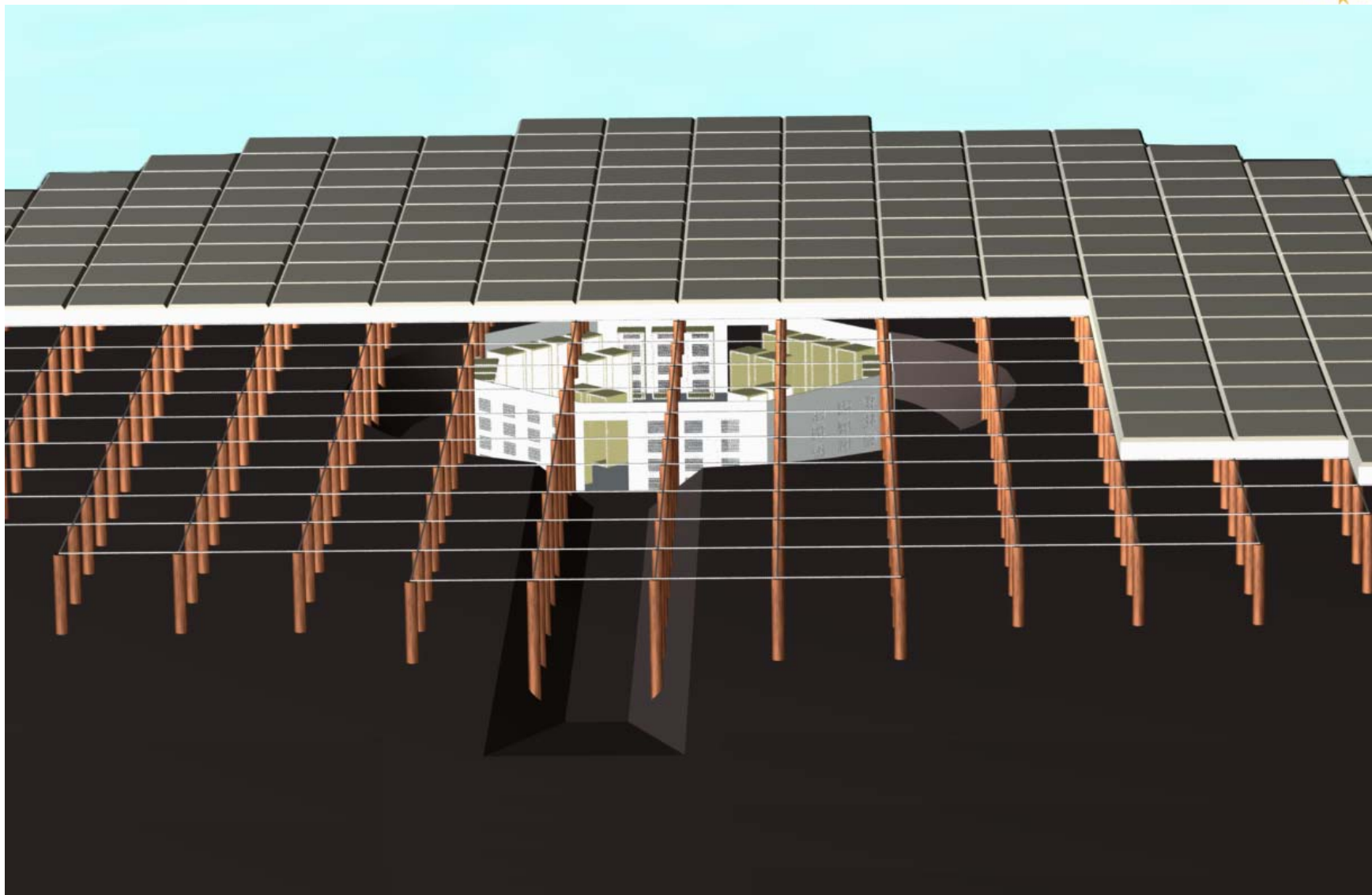
- Design using "off the shelf" components where possible
 - Simplifies design and manufacturing activities
 - Minimises inventories
 - Standardises handling and assembly operations
 - Lower manufacturing costs
 - Improves quality
- Benchmarking
 - Is there another company that makes something similar?
 - What could I learn from them?
 - Could they make it for me?

System Design

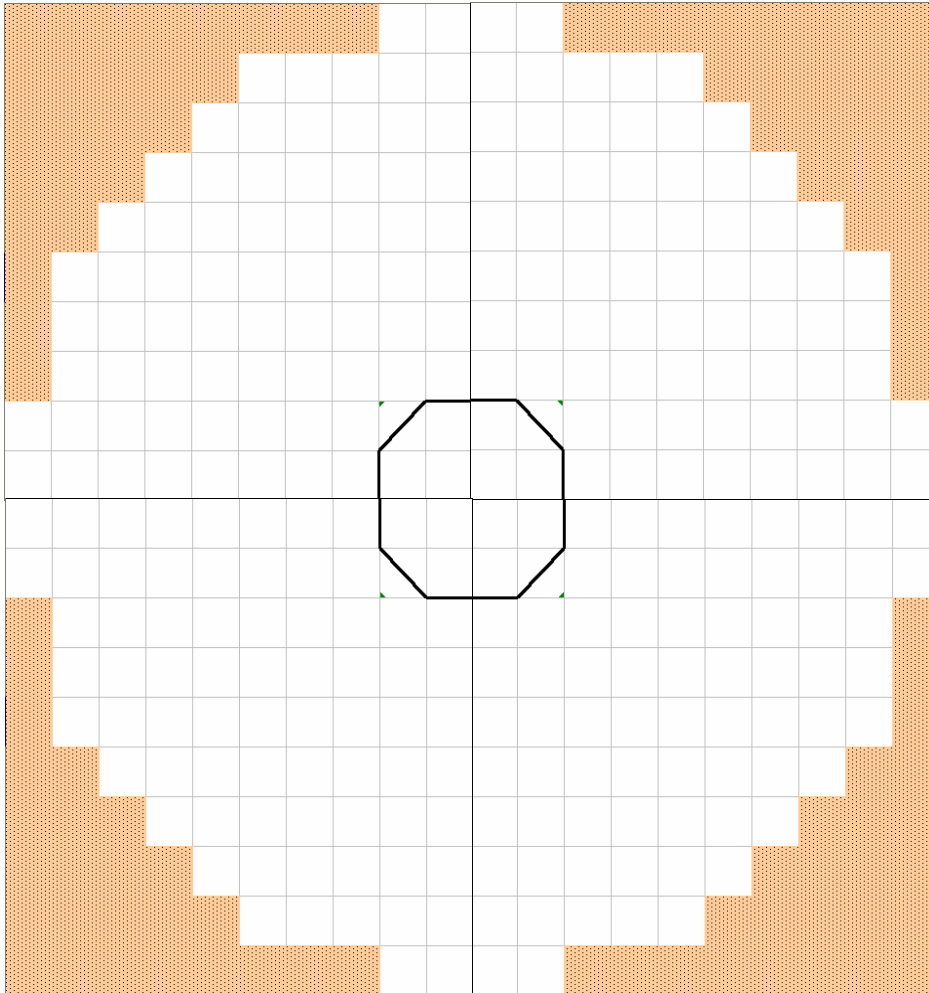


- Design for ease of fabrication
- Design so that the components can only be assembled in the correct way
- How long is it going to take me to assemble this on site or am I shipping it ready assembled?
- Are the materials that I am using cheap and plentiful (in the locations I am hoping to manufacture)?

Processing Bunker



AA-Hi Large Bunker



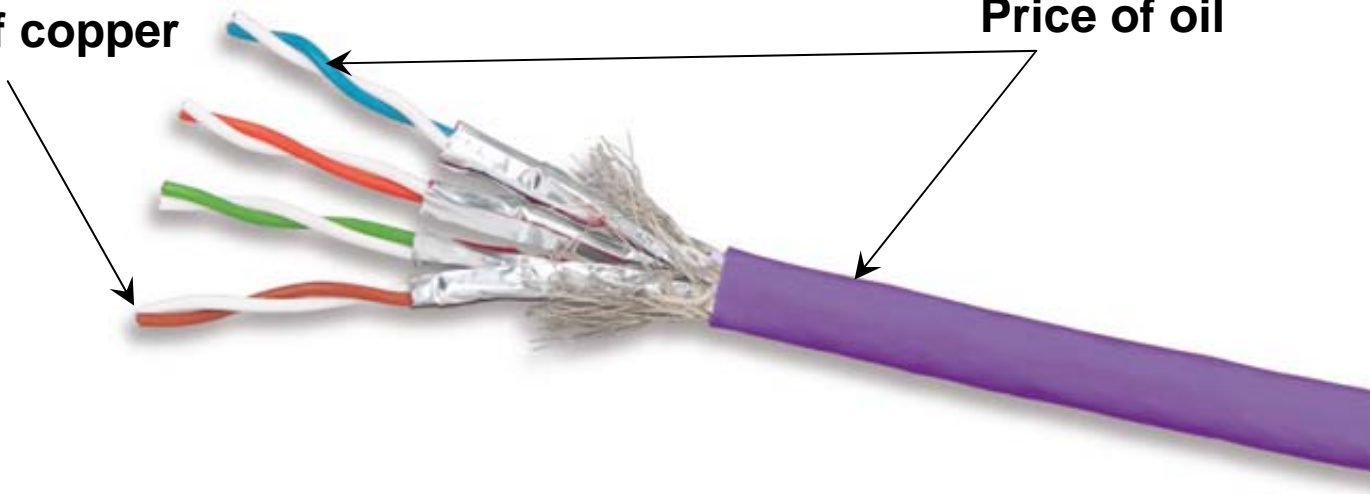
- 804 km of cable
- Average cable length of 20.9m

CAT7 Cable Costs

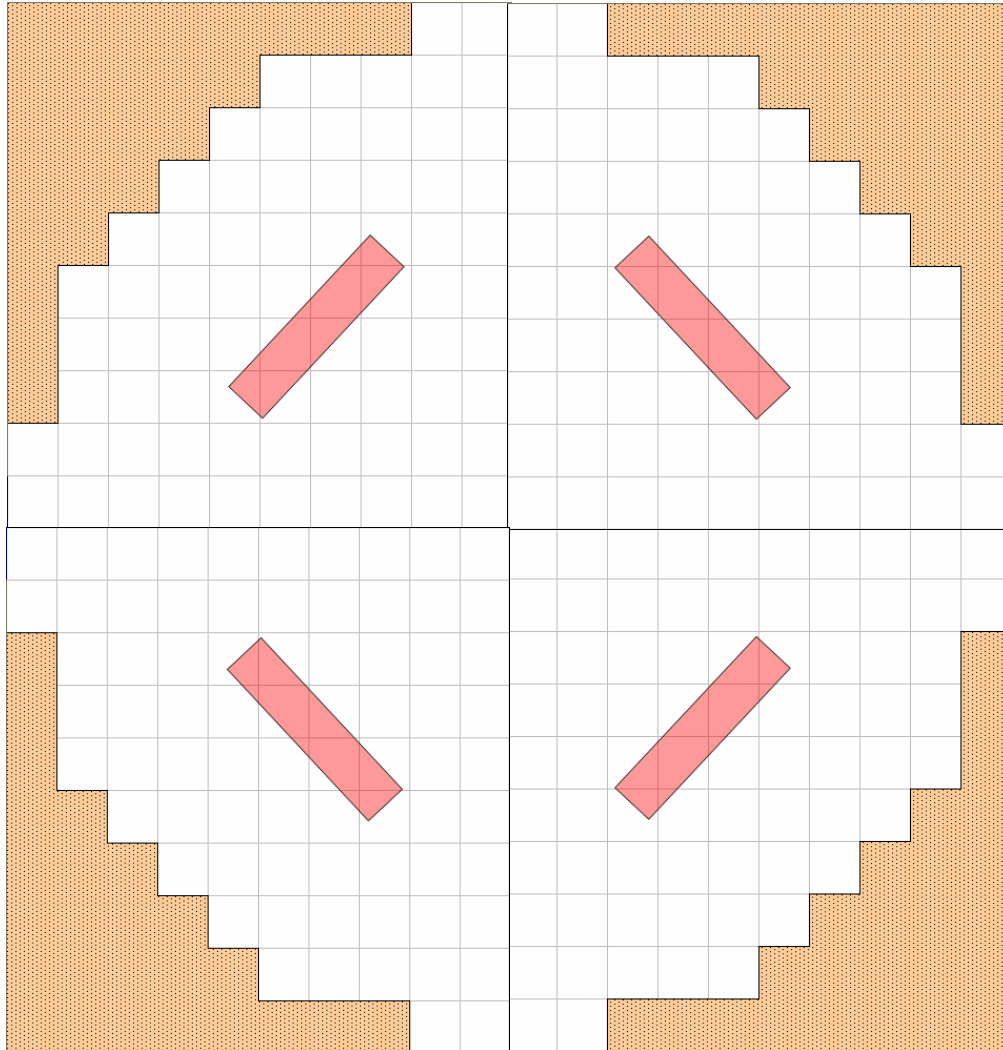


Price of copper

Price of oil

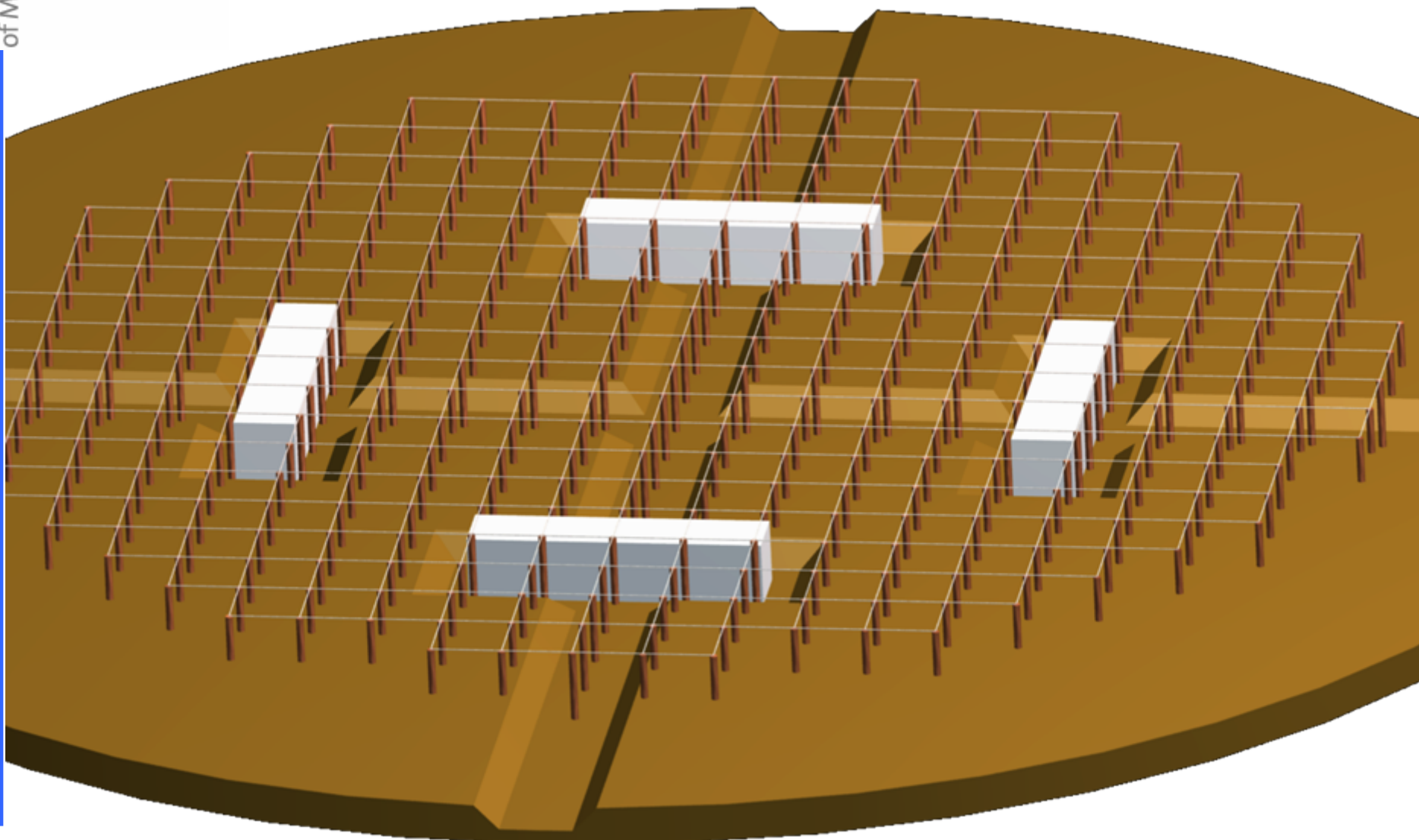


AA-Hi Bunker Layout



- 508 km of cable
- Average cable length of 13.7m

Potential SKA Station Layout



What components do the bunkers need?



- RFI Shielding sufficient to prevent noise from the electronics in the bunker reaching the antennas
- Entrance to the bunker (door?)
- Mechanism of passing antenna signals into the bunker
- Transportable

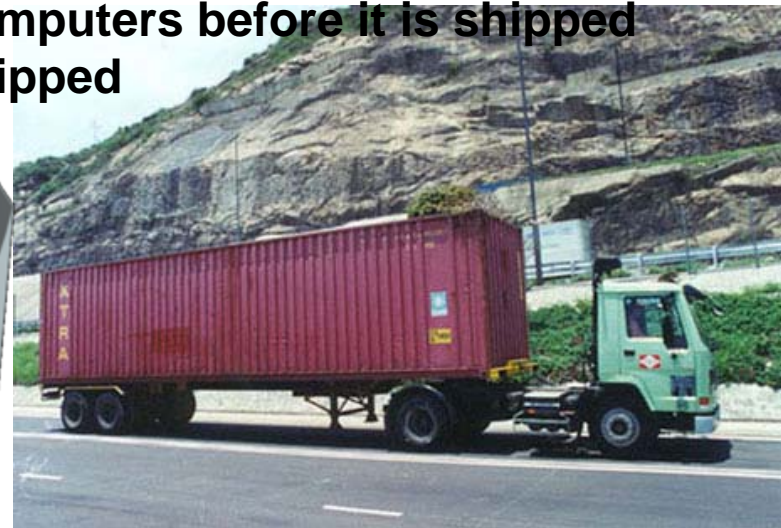
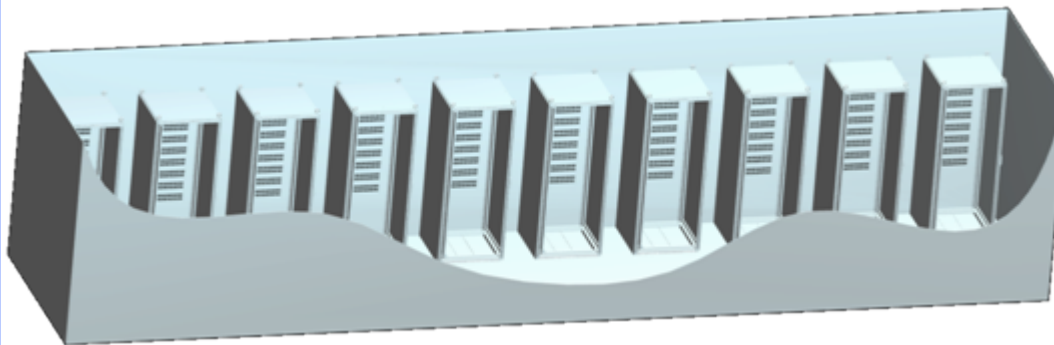
Processing Bunker



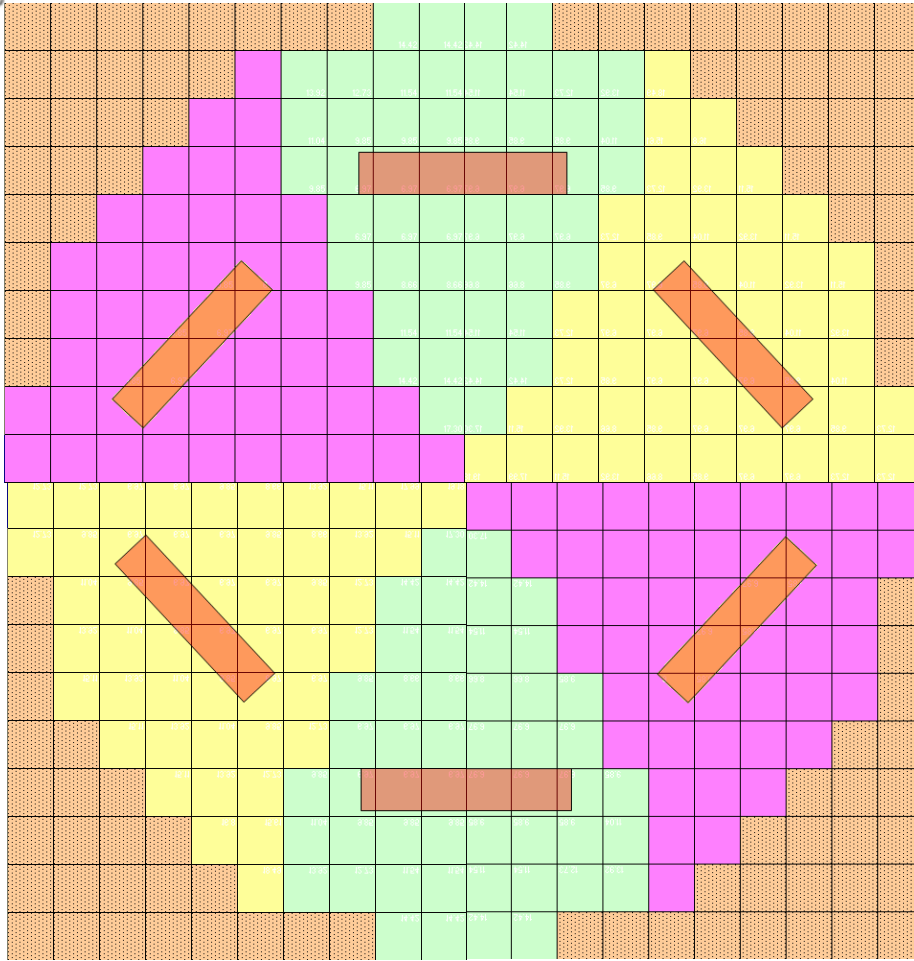
The processing bunker will be manufactured to the basic pattern pattern of a standard transport transport container.

Dual Function:

1. Provide RFI Shielding
2. Permits the processing bunker to be filled with computers computers before it is shipped shipped



AA-Hi Bunker Costs



- 445 km of cable
- Average cable length of 11.9m