

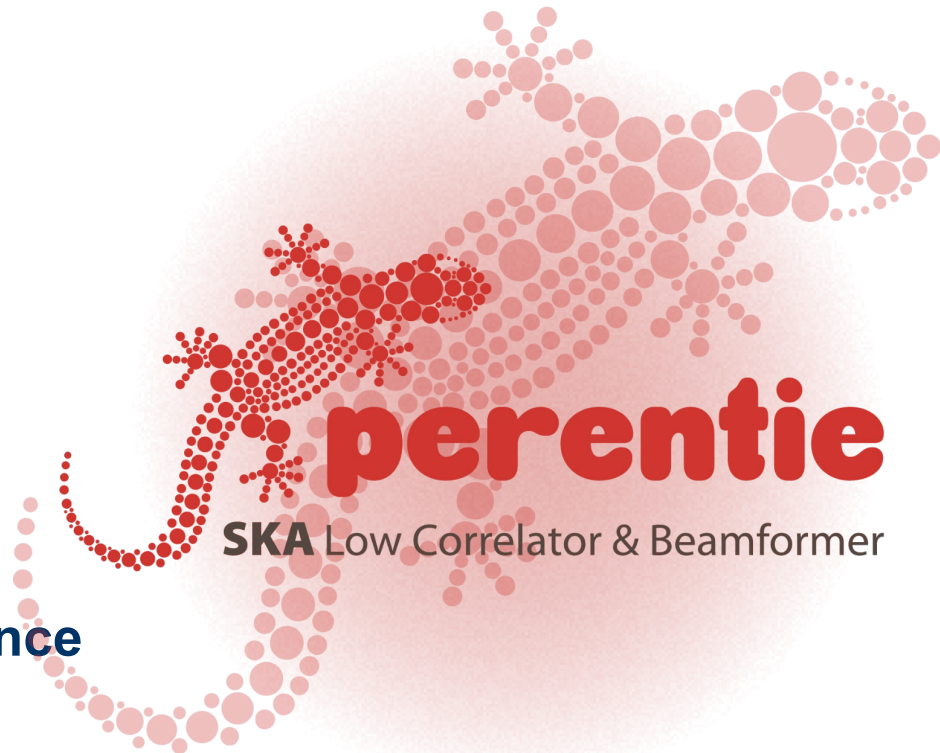


Perentie ITF and Verification Environment

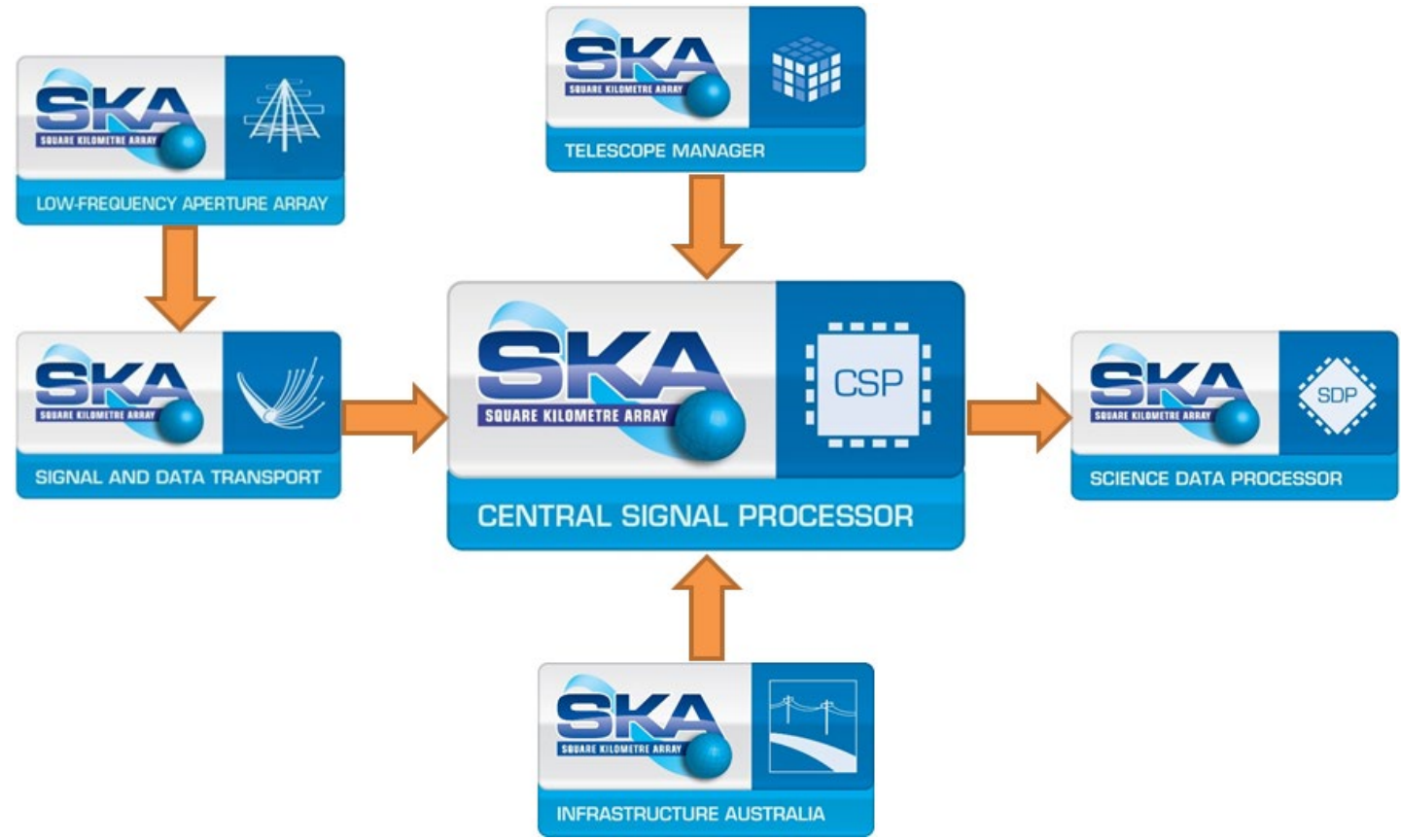
Yuqing Chen
and Keith Bengston

CSIRO Astronomy and Space Science

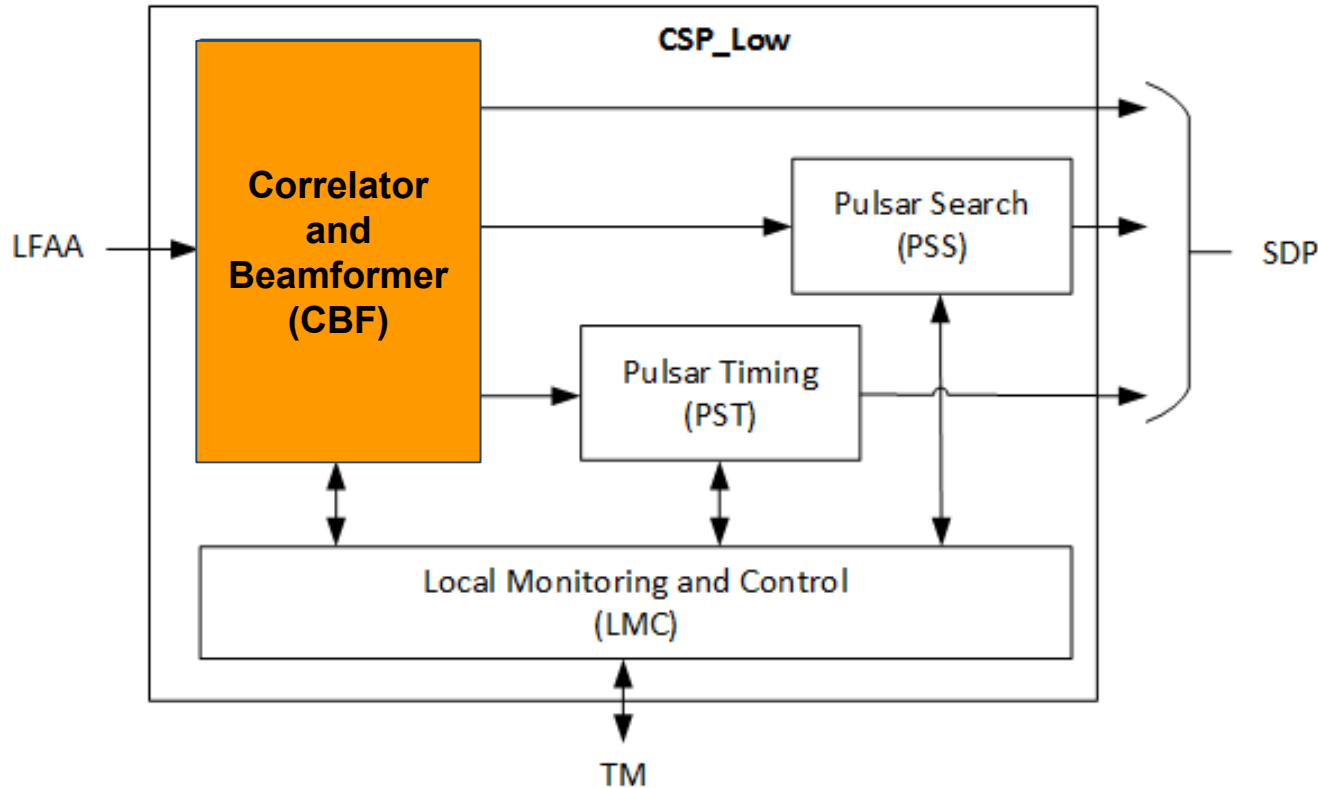
14th February 2019 - C4SKA @ AUT



SKA Low Consortia Diagram



CSP Low Sub-elements



- Low.CBF
- Low.PSS
- Low.PST
- Low.LMC

What's Perentie ITF?

- Integration and Test Facility

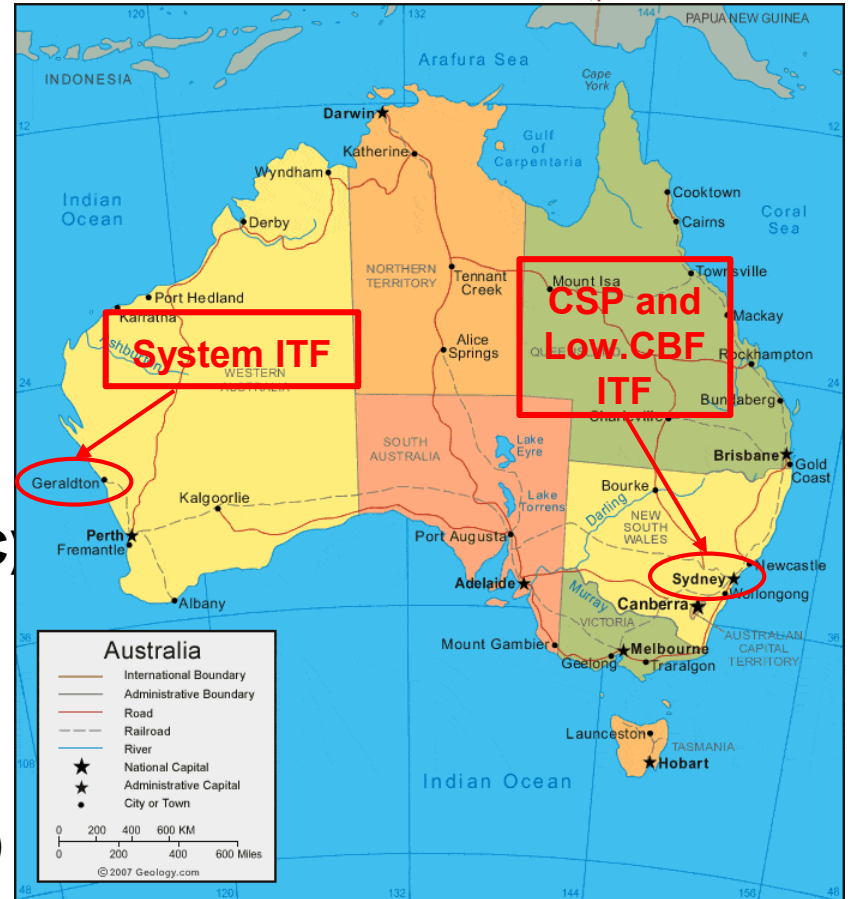
- **Emulate Site Infrastructure**
 - Power - 3-phase 400VAC, 48VDC
 - Cooling - liquid and air
 - Rack - space, cabling, plumbing, etc
- **On-going Development Platform**
 - Hardware implementation
 - FPGA firmware
 - M&C software (MACE)
- **Integration and Verification Platform**
 - Sub-element: LMC, PSS and PST
 - Element: LFAA, SDP, INFRA



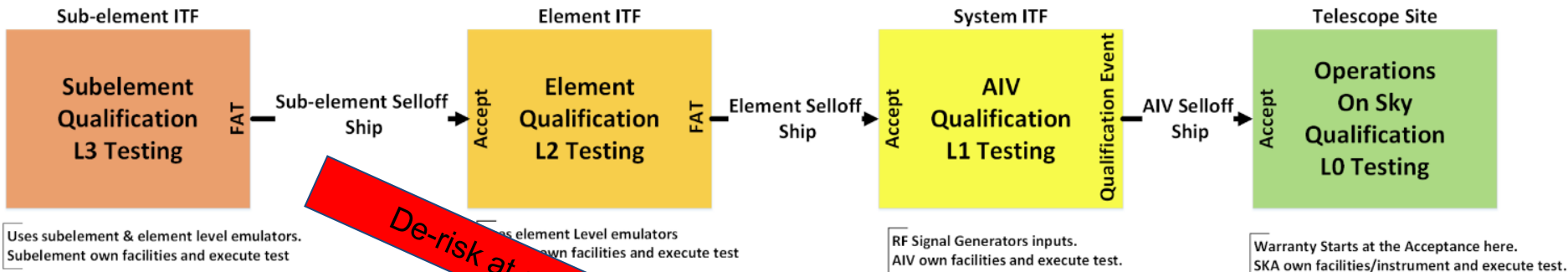
SKA ITF Locations



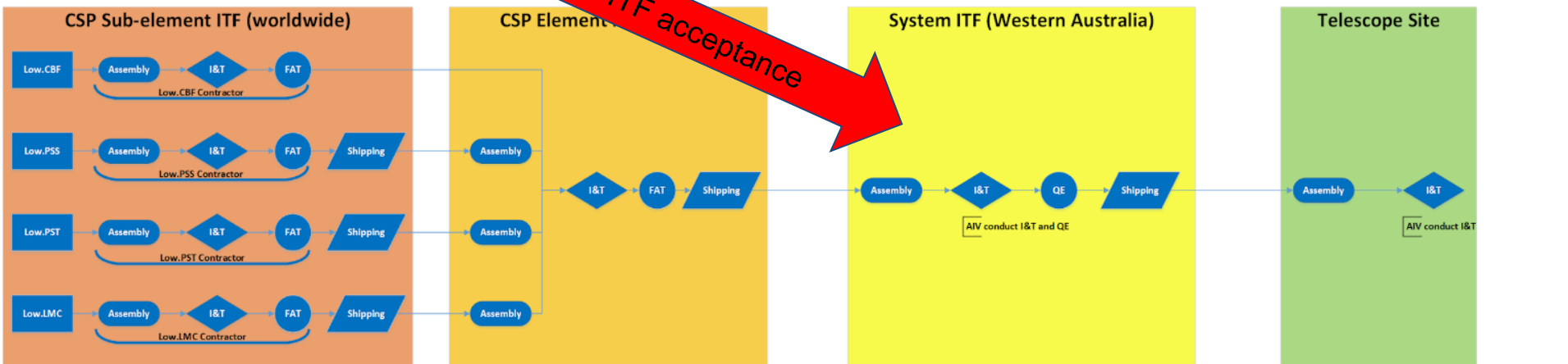
- Three levels of ITF for CSP
 - Sub-element - Low.CBF
 - Element - CSP
 - System - Telescope
- Low.CBF and CSP ITF: Sydney
 - Low.CBF activities (Internal ops)
 - CSP activities (CBF, PSS, PST, LMC)
- System ITF: Geraldton
 - System activities (LFAA, CSP, SDP)



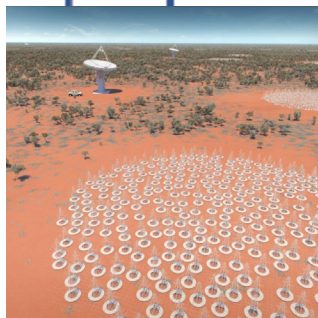
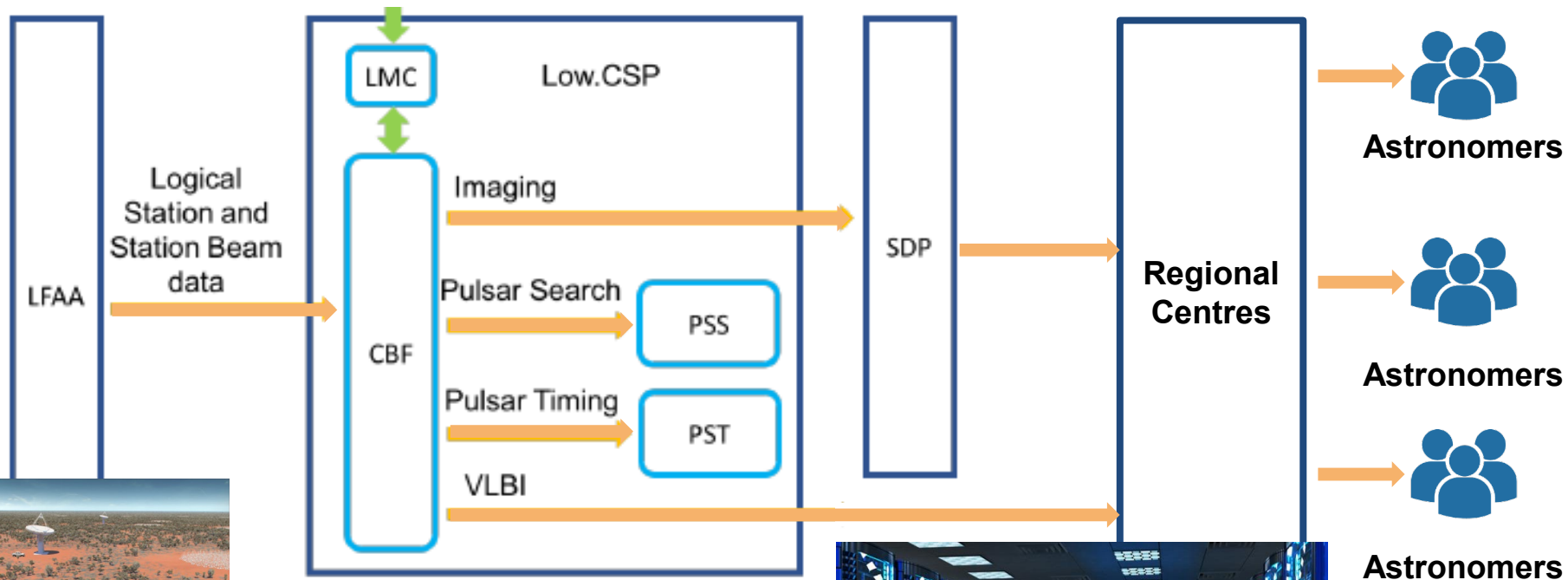
SKA Construction Phases



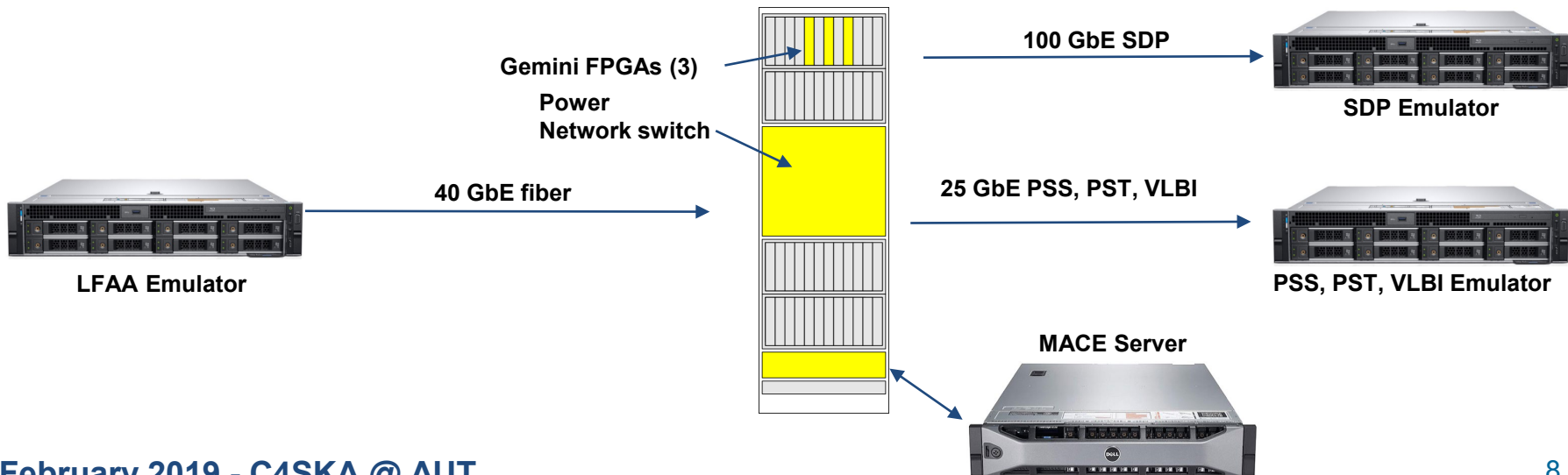
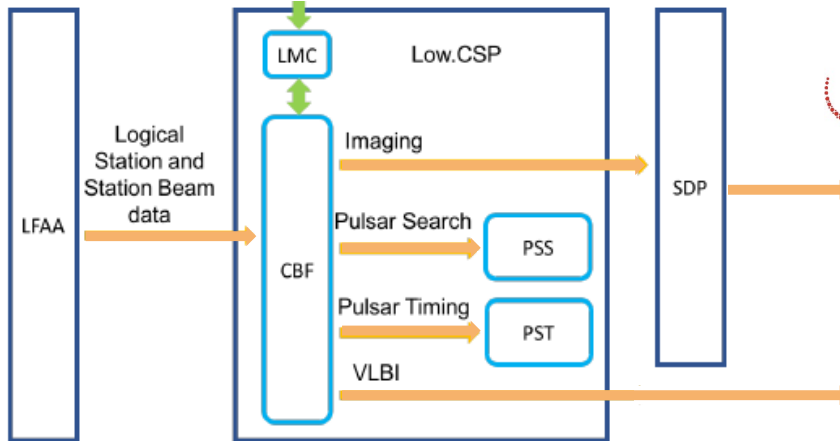
De-risk at each ITF acceptance



CSP Low Overview



Low.CBF ITF Overview



Low.CBF ITF Today



Emulator servers

Gemini Subrack

Xilinx Dev Boards

Timing Master

48VAC-DC

Transfer Switch

Network Switch

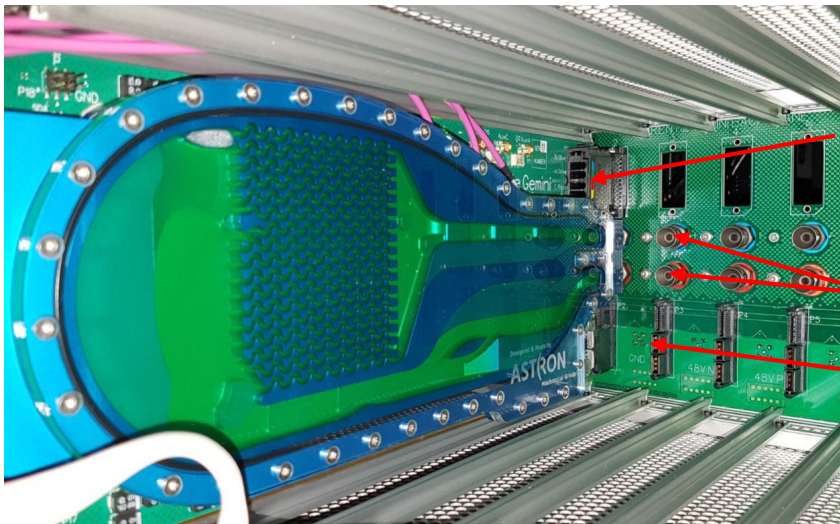
MACE Server

Liquid Cooling Exchanger

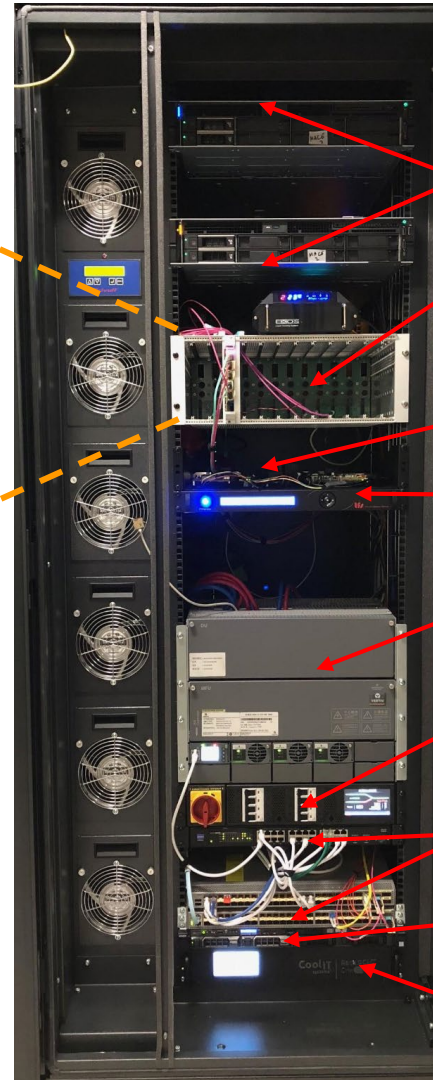
Optical Connector

Non-spill Connectors

Power Connector



- **Gemini Subrack**
 - Gemini LRU (Line-replaceable unit) + Heatsink
 - Liquid cooling and power on backplane
- **Rack Power and cooling, networking, server**
- **Sensing points (thermal, liquid)**
- **Emulator servers (LFAA, PSS, PST and LMC)**



What's happening in the ITF

Signal processing and communications

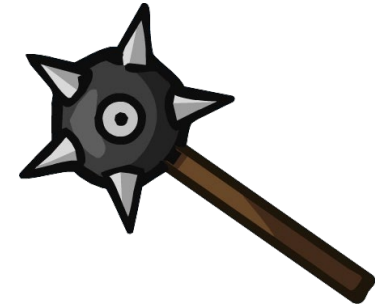
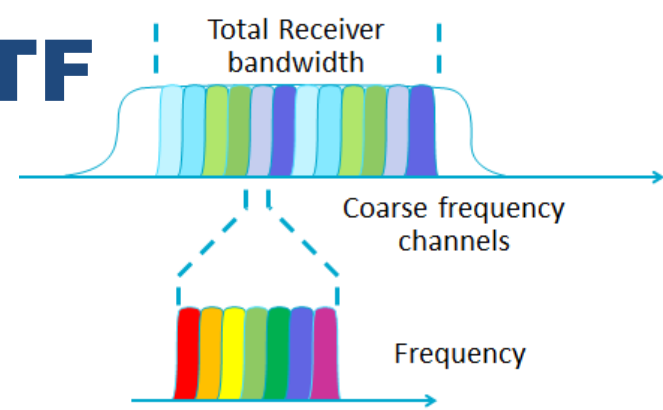
- Development DSP firmware (E.g Filterbank,COR)
- Emulation of LFAA data input from a station
- Capture and checking of Low.CBF output to SDP

Monitoring and Control Environment (MACE)

- 10GbE based network for control and monitoring of each device
- Tango based emulation of LMC
- Automated testing

Infrastructure - power, cooling, cabling

- Full redundant rack power
- Liquid cooling, leak monitoring
- Fibre, power, plumbing management



ITF Safety and Protection

- Operating in remote area
- Autonomous safety precautions
 - Automated shutdown sequence at emergency
 - Liquid cooling fail
 - Power failure
 - Failure/event logging



Initial MACE Setup



- Monitoring And Control Environment

- **MACE server and network switch installed**

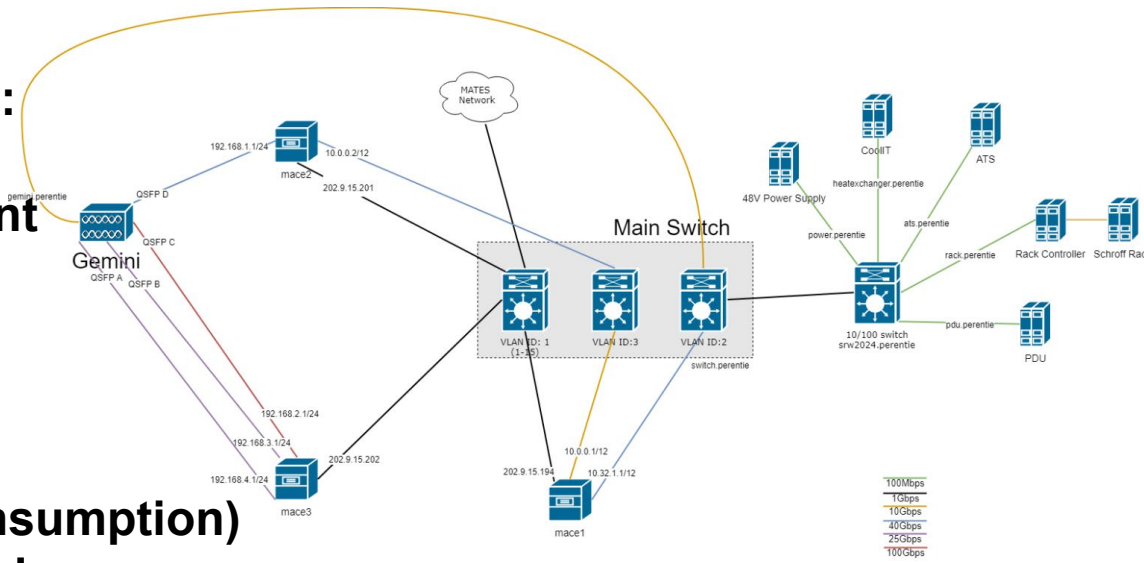
- 96 ports, 10GbE switch

- **MACE Networking connects:**

- Gemini LRU
- COTS support equipment
- Emulator servers

- **Initial M&C function**

- Gemini LRU
- COTS equipment
- Measure power (PF, consumption)
- Safety, e.g thermal shutdown



Low.CBF ITF Network Diagram

LFAA Emulator Verification



- **Sending emulated LFAA station data to Gemini FPGA card**
 - Matlab generated packets
 - Jumbo 8k packets
 - 40 GbE optical link
 - Achieved 7Gbps (with minimal effort)
- Working on optimizing the emulator performance to increase data rates so that two full stations can be on a 40G link (22Gbps)

A screenshot of the Wireshark network protocol analyzer interface. The title bar reads 'lfaa_sim_sending_enp59s0.pcapng'. The main display area shows a list of captured packets, all of which are UDP packets from source IP 192.168.1.1 to destination IP 192.168.1.2. The length of each packet is 8264 bytes. The packet list is as follows:

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
2	0.000039074	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
3	0.000044176	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
4	0.000069087	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
5	0.000071736	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
6	0.000074292	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
7	0.000077161	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
8	0.000106294	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
9	0.000109287	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
10	0.000111833	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
11	0.000114501	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
12	0.000117426	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
13	0.000120040	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
14	0.000122933	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
15	0.000171724	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
16	0.000206559	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
17	0.000210781	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264
18	0.000235778	192.168.1.1	192.168.1.2	UDP	8308	38144 → 30333 Len=8264

The packet details pane shows the selected packet (No. 2) is an Internet Protocol Version 4, User Datagram Protocol, Src Port: 38144, Dst Port: 30333. The data field shows a large block of hexadecimal data representing the 8264-byte payload.

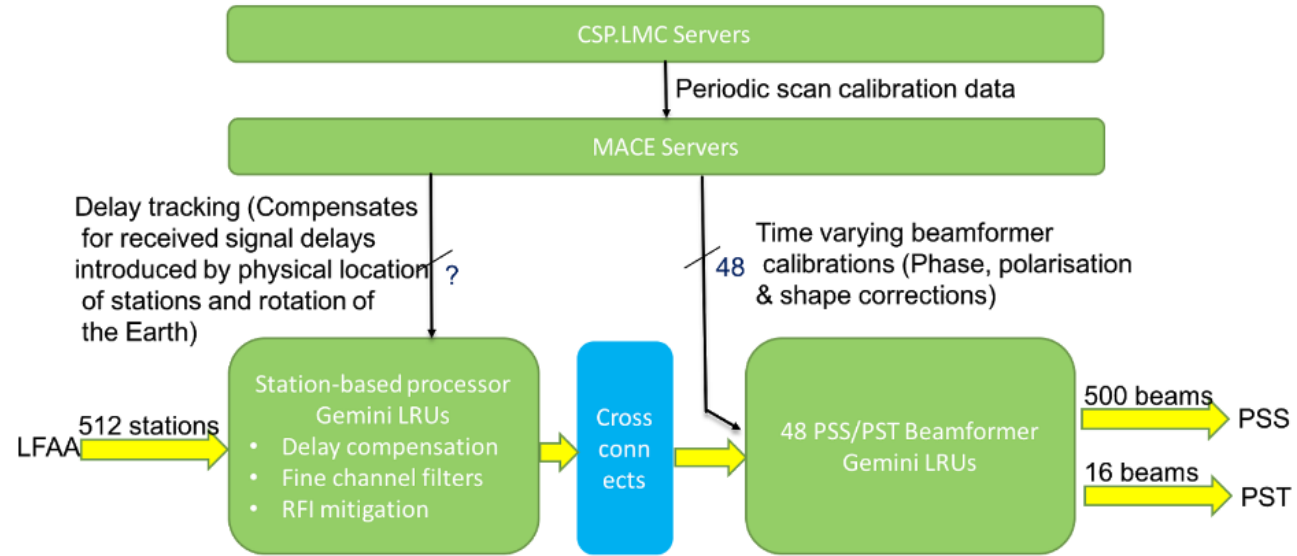
```
0000 00 04 00 01 00 06 50 6b 4b 57 1d 20 00 00 08 00  ....Pk KW. ....
0010 45 00 20 64 05 09 40 00 40 11 92 2c c0 a8 01 01  E. d. .@. @. ....
0020 c0 a8 01 02 95 00 76 7d 20 50 a3 b5 53 04 02 06  ....v} P. S.
0030 00 00 00 08 80 01 00 01 00 00 00 00 80 04 00 00  .....[.n. ....
0040 00 00 00 00 90 27 00 00 5b 6a f8 6e 9e 00 00 00  .....r&. ....
0050 00 00 00 00 90 11 00 00 03 72 26 14 b0 00 00 00  .....J. ....
0060 00 01 00 4a b0 01 01 01 00 01 01 00 b3 00 00 00
```

MACE Verification



- **Verify communication between MACE server and Gemini FPGA Card**
 - **Achieves ~5Gbps throughput over 10GbE**
 - **Able to update Jones polarisation matrices in real time**

Now also considering a multicast update mechanism to reduce server load



Perentie Initial Engineering GUI



- Initial steps toward Tango controls GUI
 - End-to-end functionality
 - GUI for low-level access to FPGA registers via network
 - Access to parameters in FPGA devices

FPGA 10.32.0.1:30000 [/home/ben258/development/perentie-software/gemini-viewer/kcu10... x

BaseAddr: Length:

peripheral	base	Register	Address	Value
▼ system				
system	0x00000000		0x00001800	0x00000080
▼ sfp				
sfp	0x00000400		0x00001801	0x00000002
▼ dhcp				
dhcp	0x00000800		0x00001802	0x00000000
▼ gemini_subscription				
client[0]	0x00000c00		0x00001803	0x00000000
client[1]	0x00000c09		0x00001804	0x00000000
client[2]	0x00000c12		0x00001805	0x00000000
client[3]	0x00000c1b		0x00001806	0x00000000
broadcast	0x00000c24			
▼ system_monitor				
system_monitor	0x00001000			
▼ ethernet_mace				
statistics_rx	0x00001800			
statistics_tx	0x00001807			
▼ demo				
client	0x00002000			
▼ axi4_quadspi_prom				
axi4_quadspi_pr...	0x00002807			

[ACK] FailCode: 0x80

What's next?

Hardware

- Gemini HBM pre-production (x5)
- Implementing optical cross connect HW
- Complete cabling and plumbing distribution

Software

- Function to capture outputs of FPGA
- More complete LMC Tango software

Firmware

- More DSP
- Communications
- Memory buffering (HBM)

Sub-element integration (ICD)

- With LMC, PSS, PST





ITF Head Start Benefits



Risk reduction:

- Demonstrate that system design meets requirements
- De-risk internal and external interfaces earlier
- Verify construction roll-out schedule



Development:

- Develop hardware, firmware and software under site environment
- Continuous test and verification of software and firmware during development

Safety:

- Demonstrate system behaves in exceptional circumstances
- Prove fail-safe condition during environmental extremes

Questions / Discussion?

Thank-you!



Super zig-zag road but a strategic life supply line (WW2)