



The Origins of SpaceWire

ISWS 2003, ESTEC

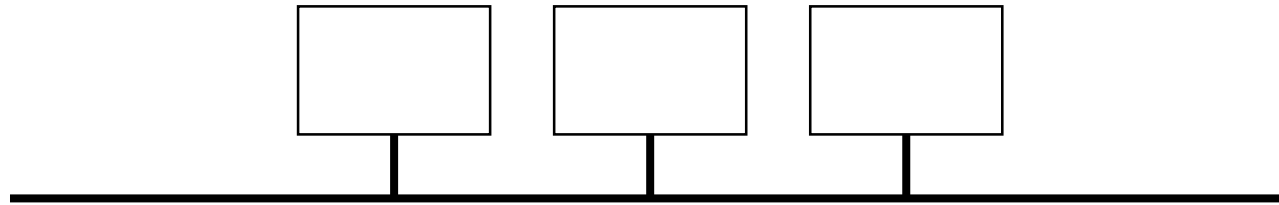
4/5 November

Paul Walker

4Links Limited

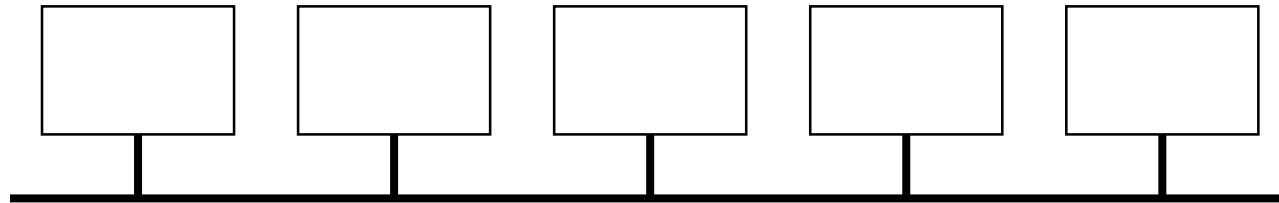
www.4Links.co.uk

The Bus Problem



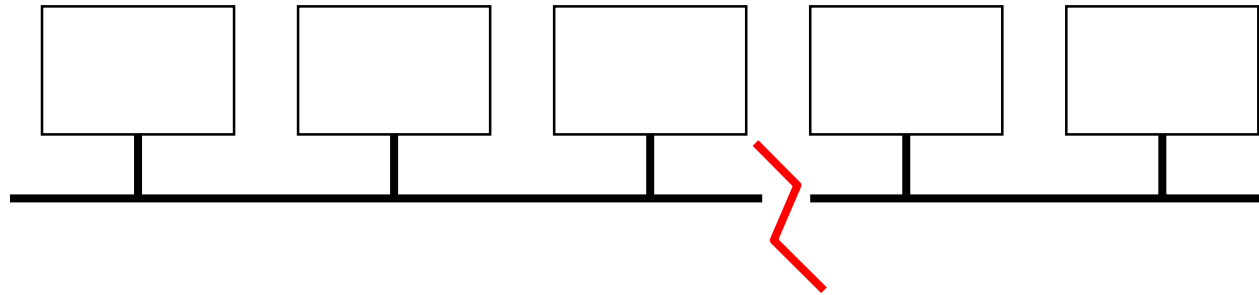
- 3 nodes: Bandwidth per node = $X/3$

The Bus Problem



- 3 nodes: Bandwidth per node = $X/3$
- 5 nodes: Need $X/3$ per node
Only get $X/5$ per node

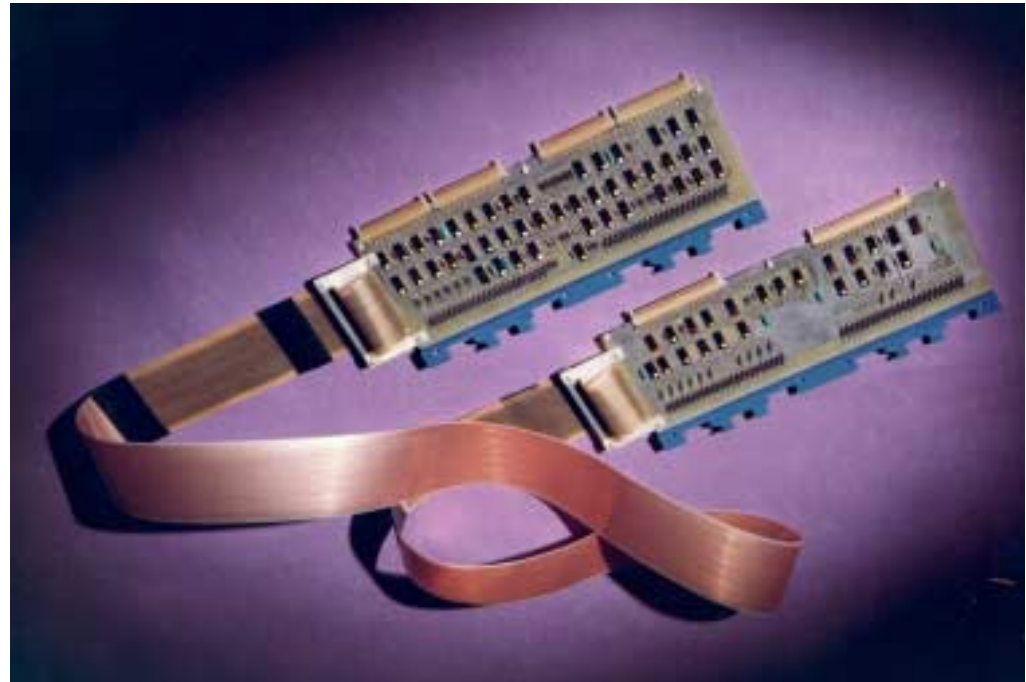
The Bus Problem



- 3 nodes: Bandwidth per node = $X/3$
- 5 nodes: Need $X/3$ per node
Only get $X/5$ per node
- Bus is single point of failure

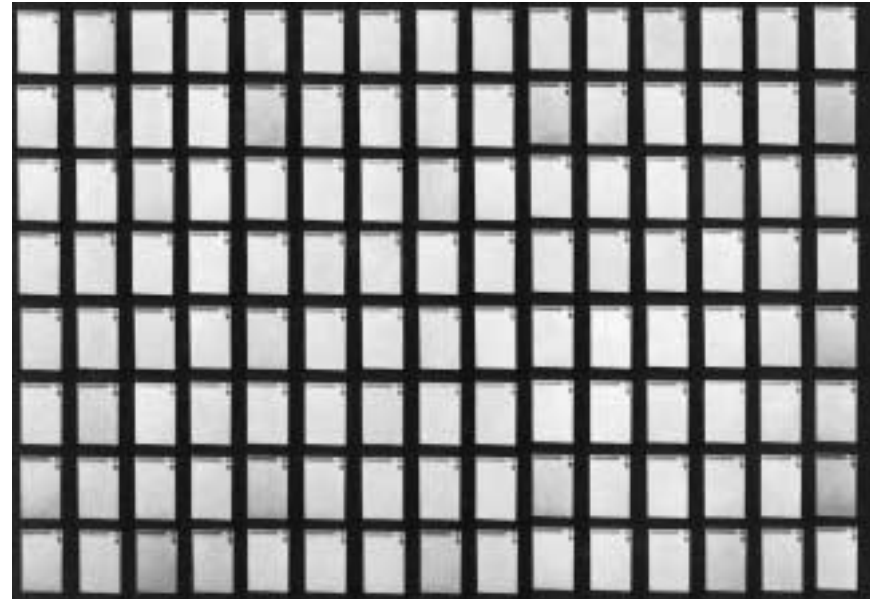
Modular One solution

4Links



- Asynchronous, Symmetrical, Point-to-point Interface

Modular One solution

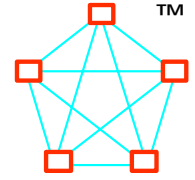


- Asynchronous, Symmetrical, Point-to-point Interface
- ⇒ Modular, Scalable, systems

Modular Ones at ESTEC 4LinksTM

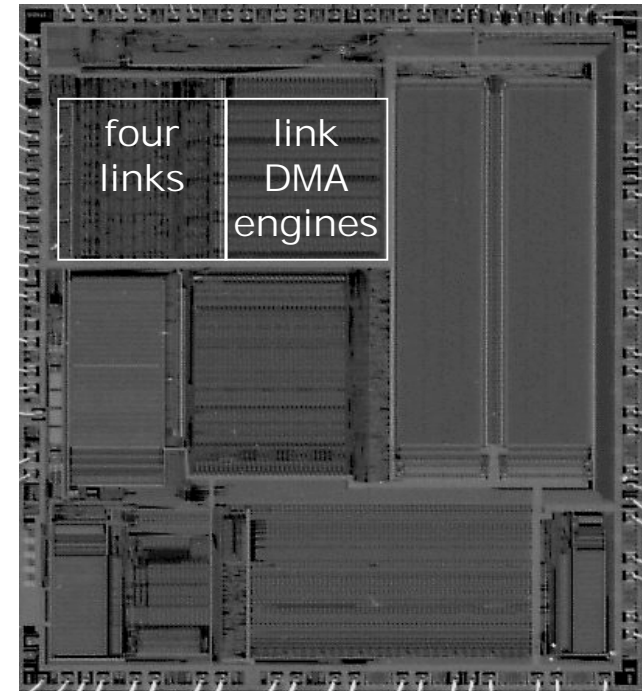
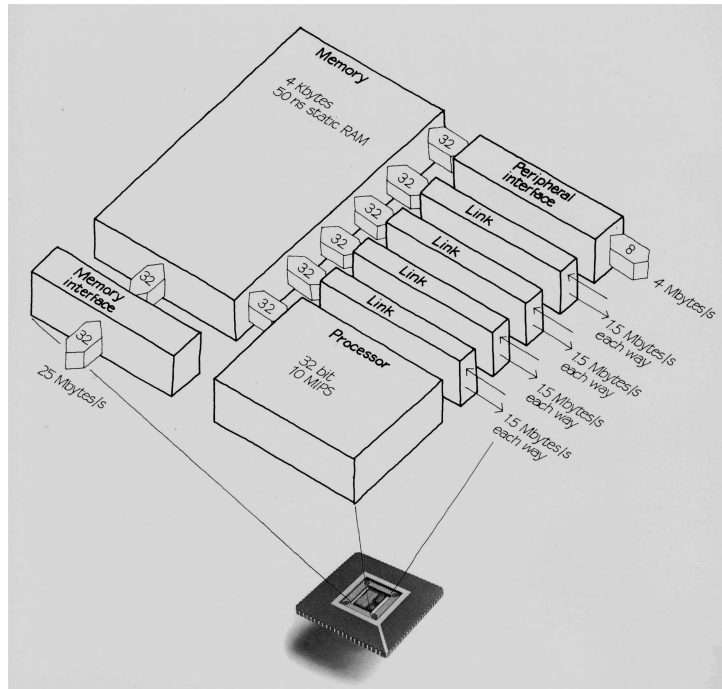


The architect of Mod 1 4Links™



- Iann Barron founded the company that built Modular One. He then wrote, in 1977:
 - “16 bits of interface are same silicon area as a processor...”
 - “This will lead to the predominance of serial interfaces
 - “They will greatly facilitate the transputer’s use, both singly and in assemblies”
- Then founded INMOS to build the transputer

Transputers and Links



- Asynchronous, Symmetrical, Serial Point-to-point Interfaces
- Plus Integrated DMA, I/O instructions

Transputers in space

1: SSTL

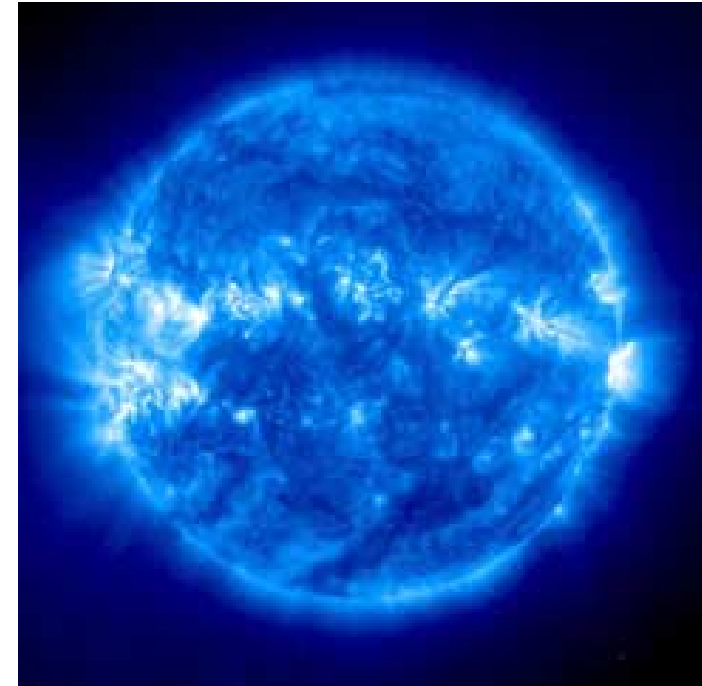
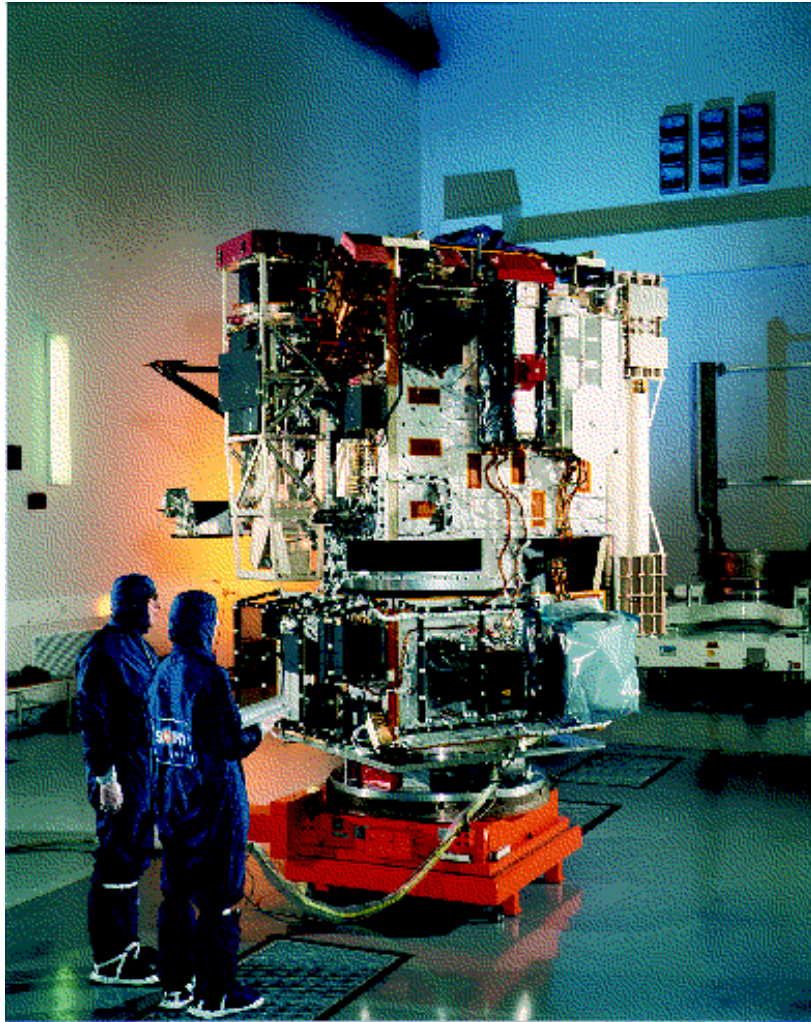


- UoSAT-4 (1990) (ESA)
- UoSAT-5 (1991) (SSTL)
- KITSAT-1 (1992)
- PoSAT-1 (1993)
- FASAT-Alfa (1995)
- FASAT-Bravo (1997)
- TMSAT (1997)
- UoSAT-12 (1999)
- Tsinghua-1 (2000)
- TiungSat (2001)



Transputers and Links

2: ESA/NASA SOHO



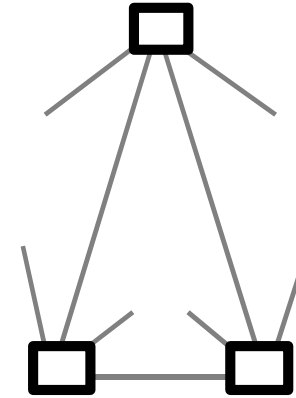
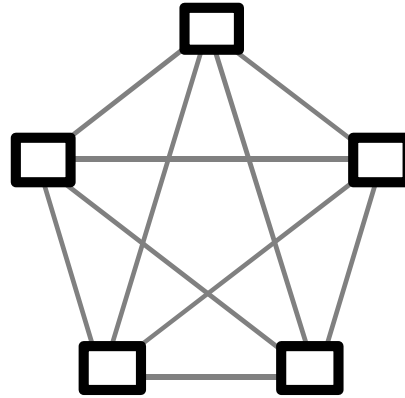
- Transputer Links used for camera interfaces

Transputers in space

3: Not Rad-Hard!



- Commercial, State of art microprocessors
- Batch tested to find best batches for space
- Used redundant transputers connected by Serial Links



- Rad-Hard by System Design

Transputer Modularity: TRAMs

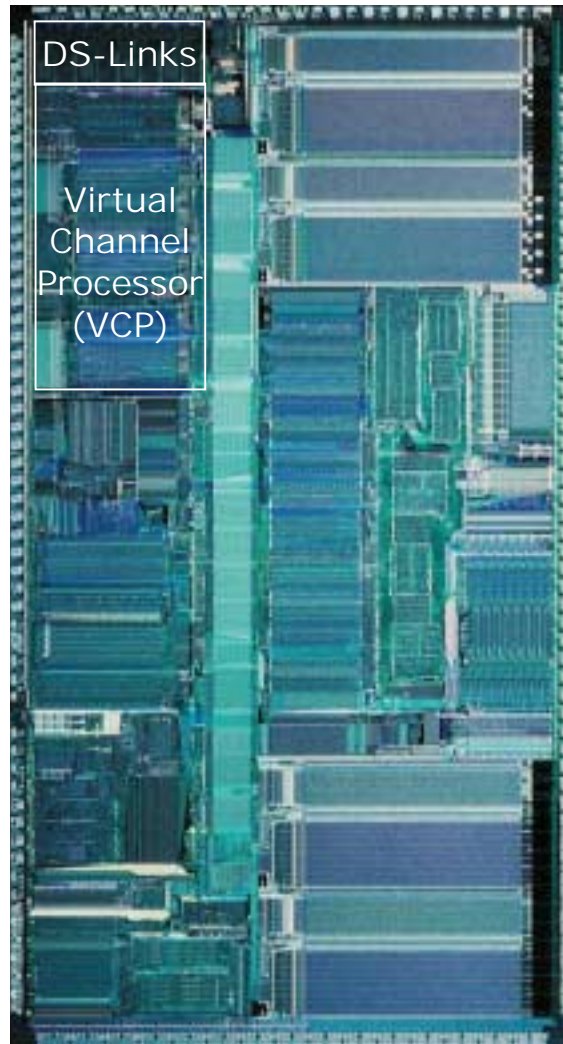
4Links



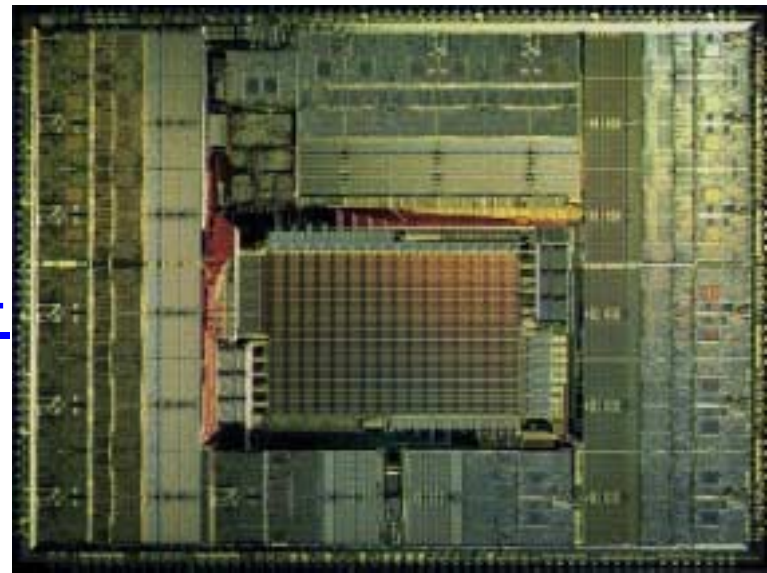
- Easy, re-use
- 16-pins
- Serial Links
- Stacked like Lego™
- Successful open standard



New Transputer, New Serial Links



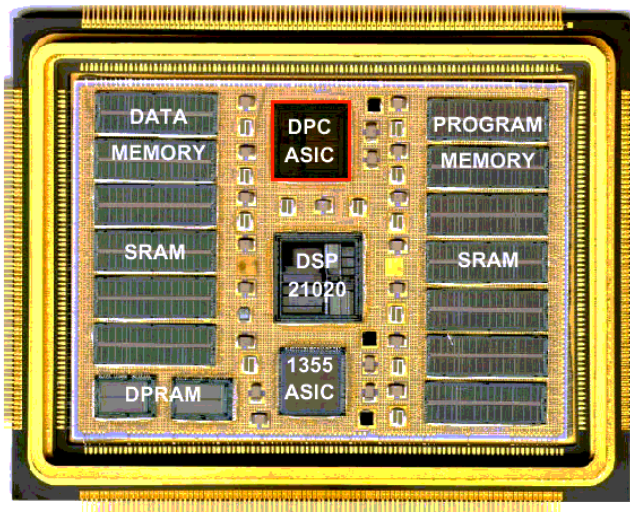
- Asynchronous, Symmetrical, Serial, Flow-Controlled, Point-to-point Interface
- Packet protocol
- Data/ Strobe
- Routing switches
- 100Mb/s+
- Modular
- Scalable



IEEE 1355



- Astrium Ottobrun: SMCS chip, Mosaic board
- Astrium Velizy: MCM-Mosaic (Like transputer)
- British Aerospace: FPGA 1355
- 4Links PCI-1355: using INMOS/ST chips
- Eonic: Virtuoso RTOS



Setback = Opportunity 4Links

- ST abandon transputers, IEEE 1355
= Opportunity for 4Links
- British Aerospace cancel 1355 FPGA project
= Opportunity for Dundee University
- Eonic agree to distribute Mosaic boards
- Held meeting at Brussels Airport
- Demonstrated critical mass
- 'Zeroth' meeting of SpaceWire Working Group

SpaceWire



	Modular One	Trans- puter	T9000	IEEE 1355	SMCS	Space- Wire
Point-to-point	✓	✓	✓	✓	✓	✓
Symmetrical	✓	✓	✓	X	X	✓
Asynchronous	✓	✓	✓	✓	✓	✓
Flow-controlled	✓	✓	✓	✓	✓	✓
Modular	✓	✓	✓	✓	✓	✓
Scalable	✓	✓	✓	✓	✓	✓
Fault-tolerant	✓	✓	✓	✓	✓	✓
Serial		✓	✓	✓	✓	✓
DMA engine		✓	✓		✓	?
Packet protocol			✓	✓	✓	✓
Virtual Channels			✓			?
Network protocol			✓			✓
Time distribution				(Fibre)		✓
Comms instructions		✓	✓			?

Vision



- Iann Barron
- T4xx transputer designers
- Designers of DS-Links in T9000 and C104
- IEEE 1355: Colin Whitby-Strevens, Peter Thompson, Bob Dobinson, Brian Martin
- Astrium/DSS: Anja Christen, Tim Pike
- British Aerospace: Steve Parkes
- Initial ESA contact with 4Links: Patrick Plancke
- Brussels Airport Meeting: Eric Verhulst
- SpaceWire: Philippe Armbruster, Josep Rosello
- Barry Cook and our colleagues at 4Links
- The SpaceWire Working Group, our customers:
most of the speakers you are about to hear!

Debt to the history



**'If it had not existed,
we'd have had to invent it!'**

**(Said to author at first meeting of the
SpaceWire Working Group)**