Biarri Networks
NETWORK OPTIMISATION

Systems provider to
NBNCo

National Broadband Network

Optimized Fibre Optic Network Design

INFORMS Franz Edelman Award 2014

Via video: Peter Ferris, Alex Grime, Luke Birch

In person: Joe Forbes, Paul Kennedy, Michael Forbes

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Operations Research

projected to **save over $2 Billion** on

Australia's largest infrastructure project

80% reduction in network design time

10% avoided costs in network construction

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NETWORK OPTIMISATION

NBN Intro

Understanding the Problem

Peter Ferris

Executive General Manager Planning and Design NBN Co.

A big country

Australia	USA
2.9M sq miles	3.8M sq miles
22M people	314M people

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Three markets, one solution

Consumer
– **Asymmetrical**

High-speed internet
- bursty

IPTV
- streaming
- constant (committed rates)

VOIP
- constant (committed rates)

Business
– **Symmetrical**
– **Business critical connection**
– **Service level guarantee**

Backup of data

Software-as-a-Service

High-definition voice and video conferencing

Online collaboration with remote workers

Industry – e.g. health
– **Symmetrical**
– **Business critical connection**
– **Service level guarantee**
– **Ubiquitous**

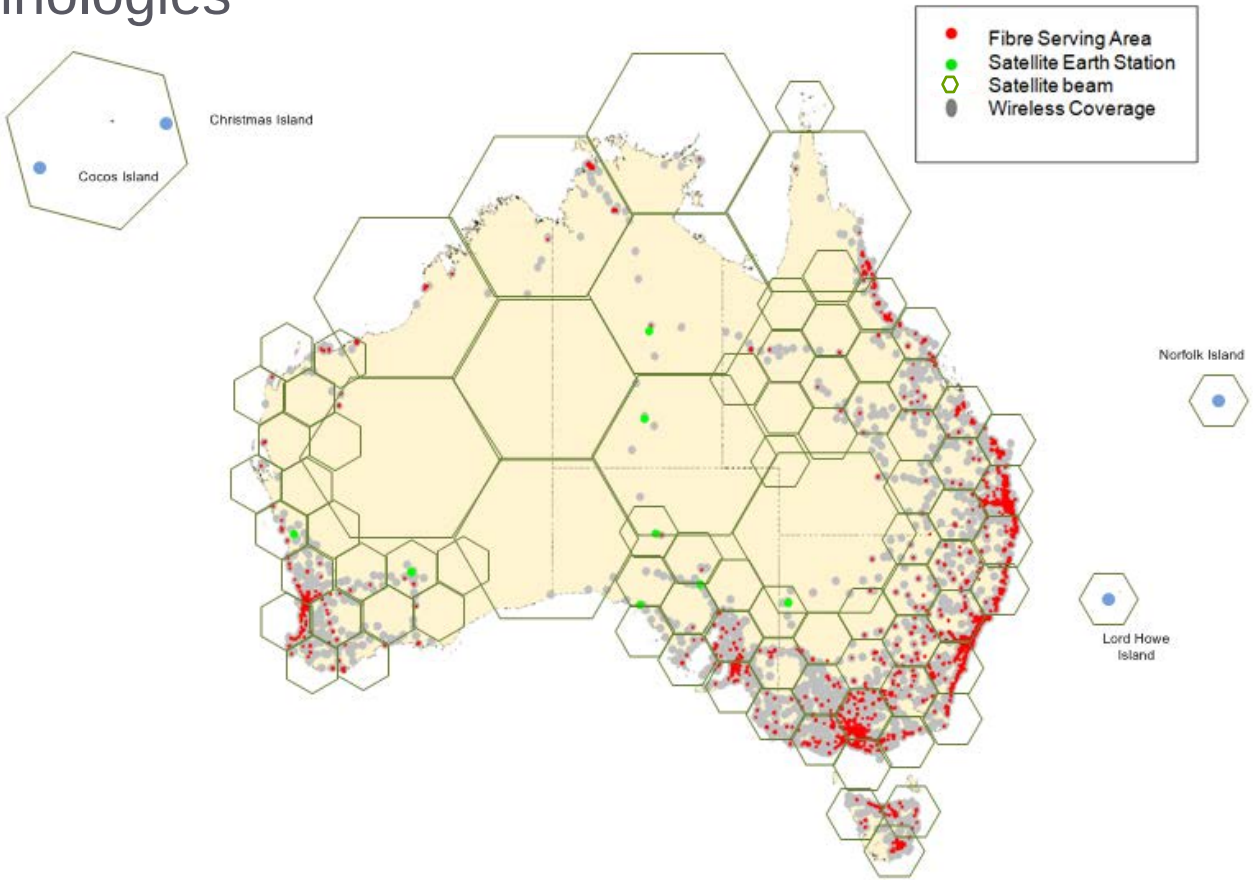
Online consultations eprescribability

Remote diagnosis of electronic medical images

In-home monitoring of elderly-chronic disease sufferers

Source: LTE/SAE Trial Initiative (Oct 2009)

Three technologies



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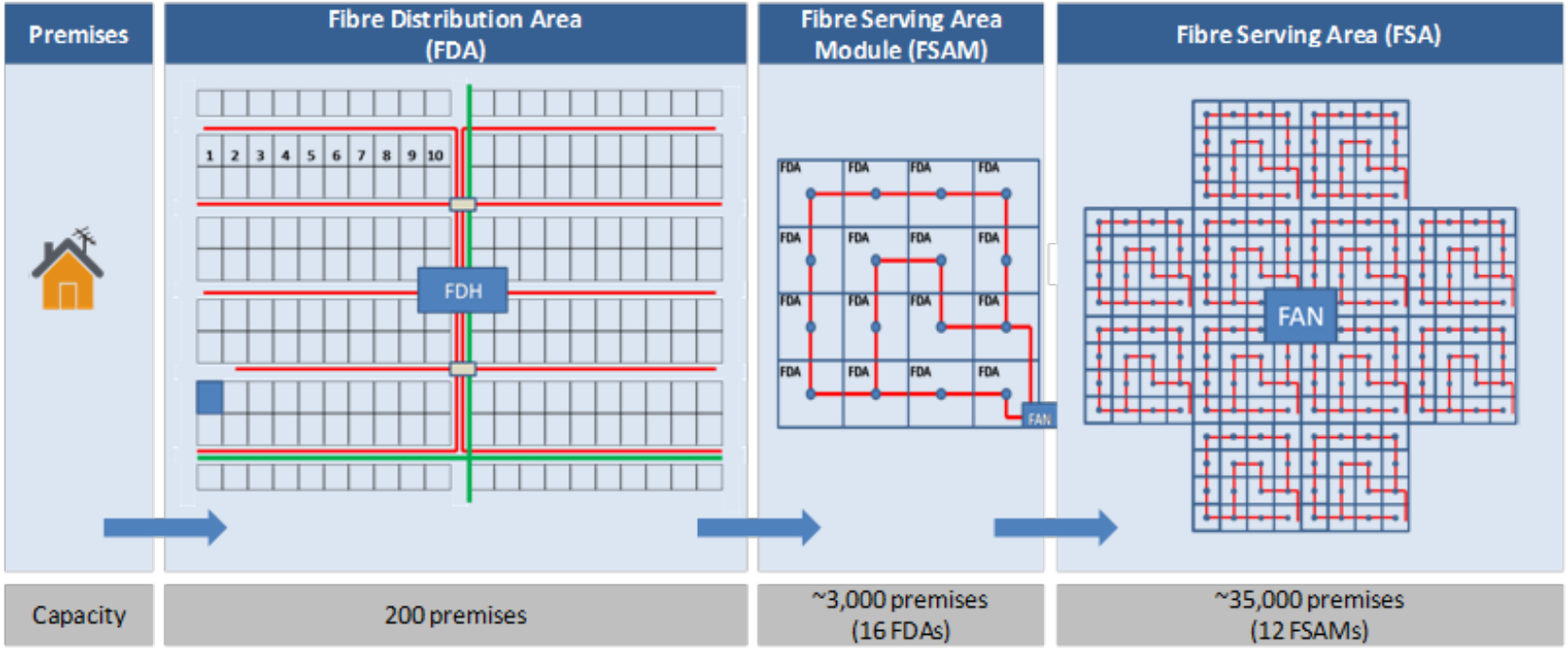
Network architecture – replicating modules



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Telstra Infrastructure Supply Agreement

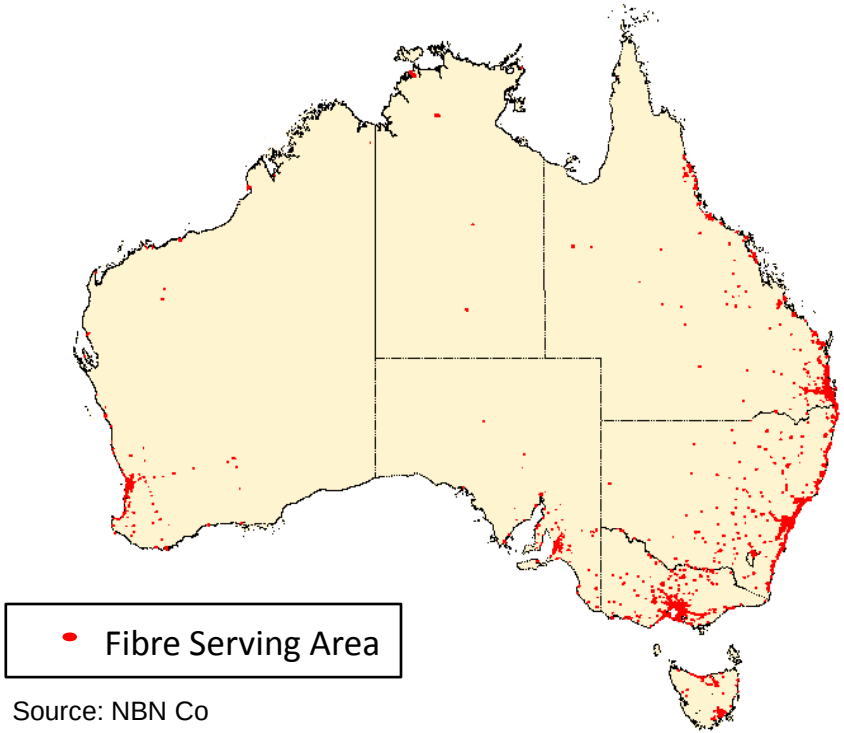
Asset	Quantity	Commercials	Use
Duct Asset	130,000 km	Leased, take or pay	FSAM
Lead-in conduit	2.7M	Purchased	FSAM
Dark Fiber Pairs	55,121 km	Leased, take or pay	Transit
Equipment Rack space	16,743 racks	Leased, take or pay	FSAM Transit

Characterising the problem

Paul Kennedy

CEO, Biarri Networks

Quantity



Source: NBN Co

FSAMs

- 4,000 FSAMs (Fibre Serving Area Modules)
- 2,500 premises in each

Rate

- Complete two FSAMs / day … every day until 2020

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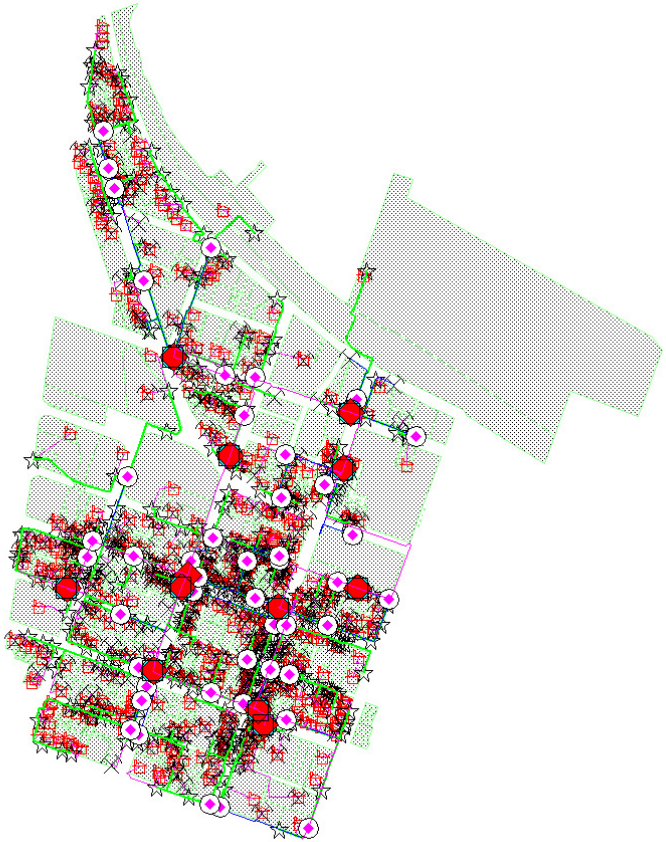
Intricacy

7000 elements in a completed design

Strict requirements

- Exhaustive
- Geometrically correct
- Fully typed and named
- Fully associated



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Complexity

Each design requires thousands of decisions

Install aerial or underground?

Use existing duct or build new?

What size components?

Where to place joints?

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Generalise the problem

- **Quantity**
  Need to design more than 4000 FSAMs

- **Intricacy**
  Each design has thousands of elements

- **Complexity**
  Each FSAM has a huge number of alternative designs

We decomposed the problem to a series of MIPs…

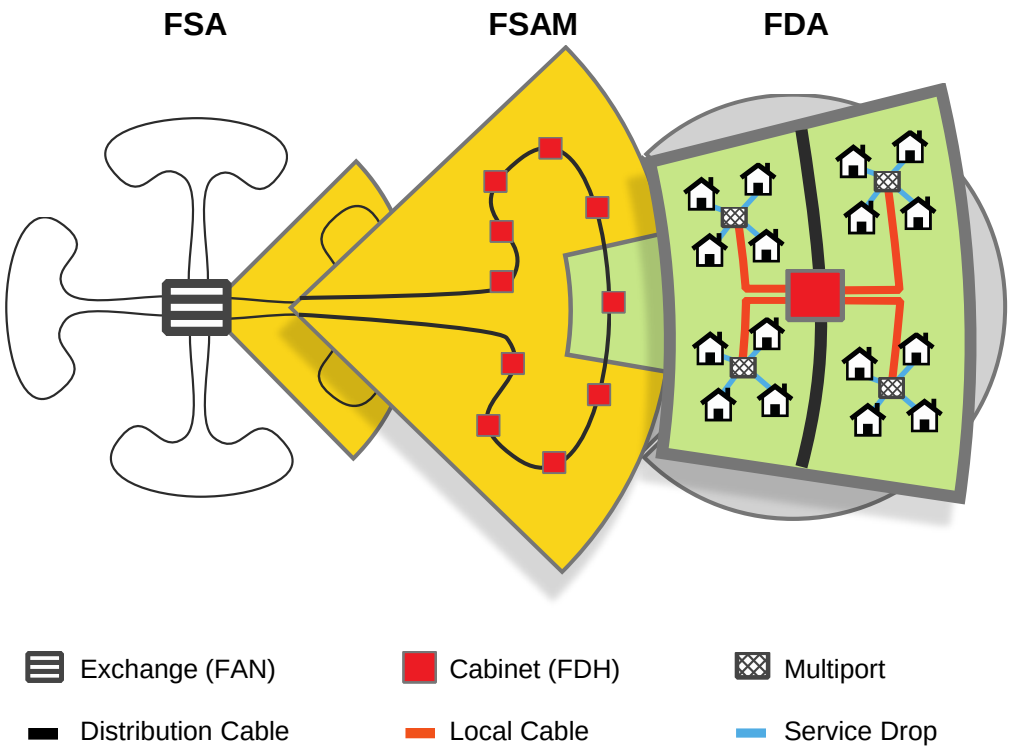
…and then built FOND (Fiber Optic Network Design) to manage the process.

Solving the problem

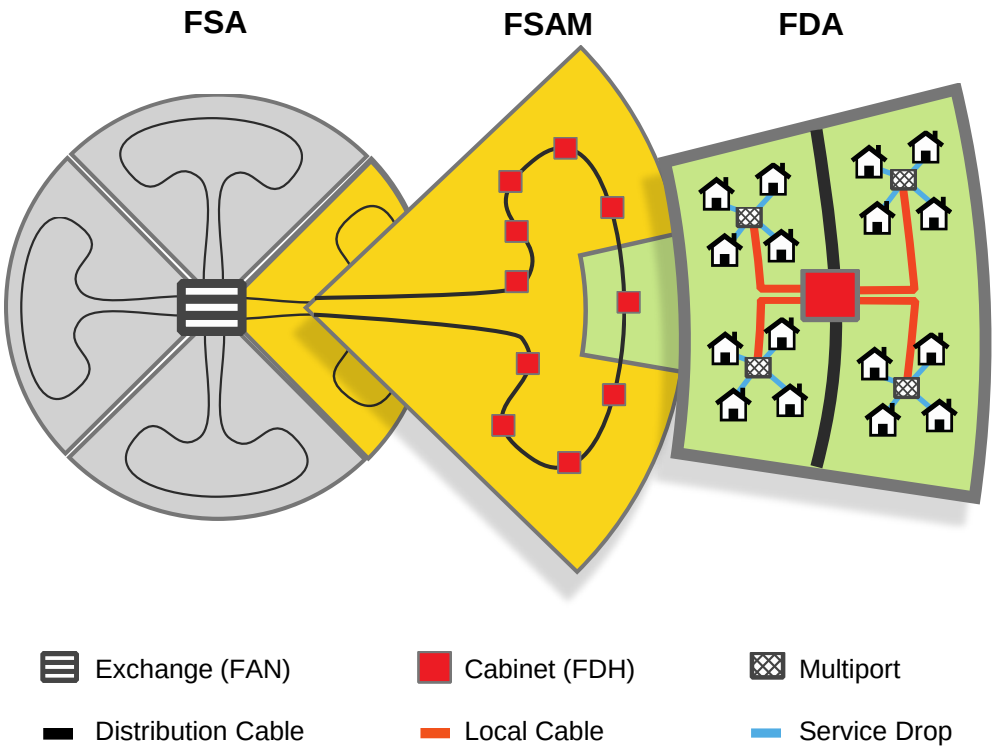
Michael Forbes

Optimisation Expert, Biarri Networks

FSAM Hierarchy

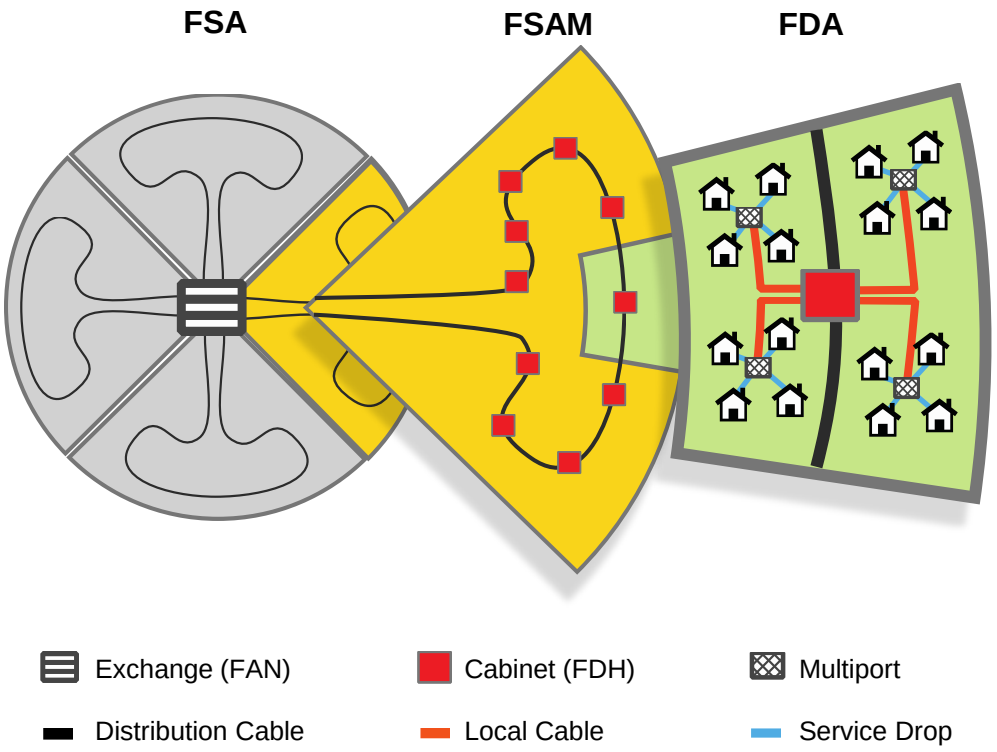


Multiport Hub Selection



- Select from candidate multiport locations and assign premises to multiports
- Hub selection MIP with option to remediate infrastructure
- 3000 premises reduced hub to 650 multiports

FDH Hub Selection



- Initial positioning of up to 16 candidate FDHs
- Hub selection MIP
- Physical location of FDHs dependent on negotiation

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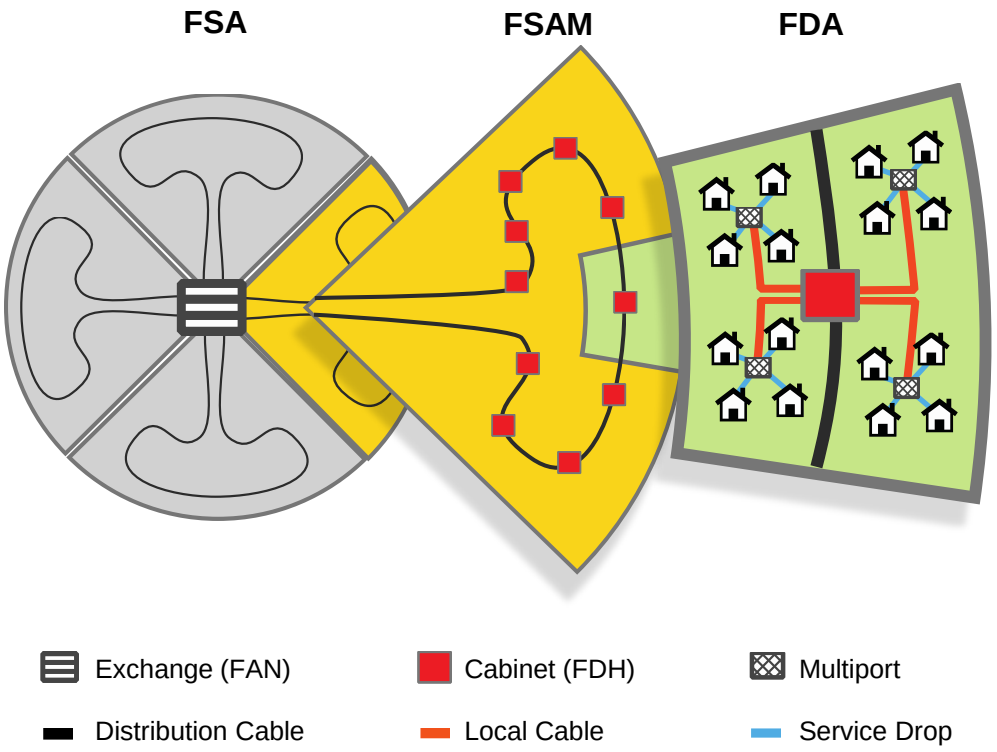
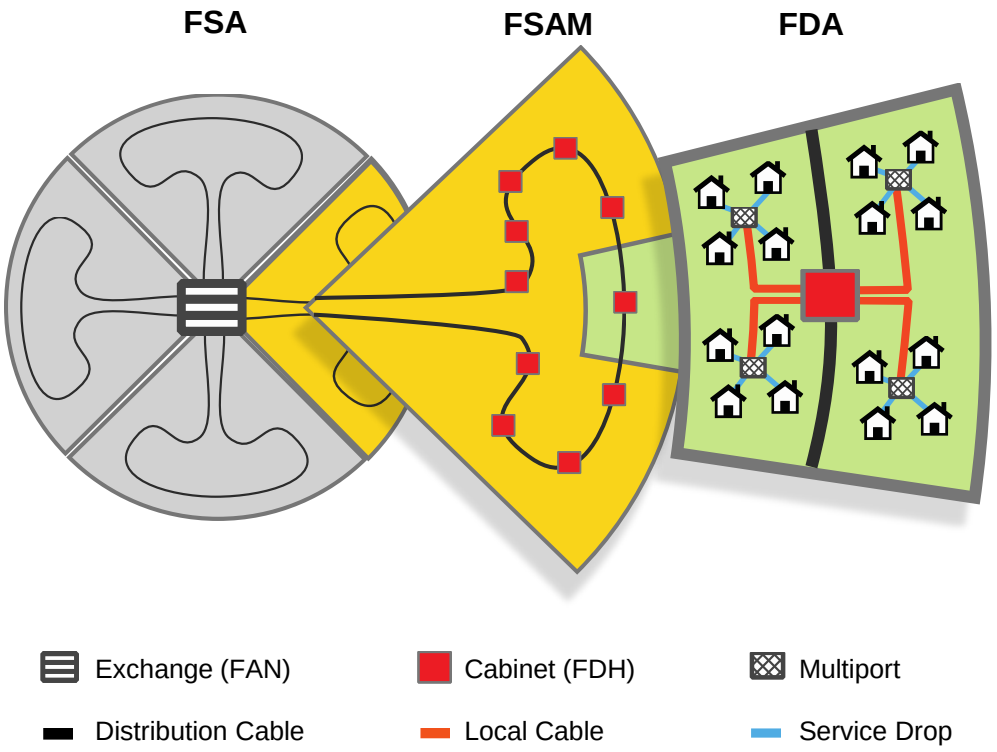
Distribution Ring



- Specially constrained TSP / VRP formulated as a MIP
- Ring can have one branch
- Paths between FDHs need to be arc disjoint, subject to side of road

FSAM Detailed Solve



- Builds the detailed network
- Large MIP model
- Can be run with many or few FDH locations
- Can be run with the distribution ring pre-specified
- Simplified architecture without loss of feasibility
- Partition network into set of capacitated trees to minimise construction cost

Integer programming techniques

Special branching variables related to the underlying undirected tree

- Is a node a potential branching point - hub or otherwise?
- Is an arc included in either direction?

MIP based heuristics:

- Run to integrality on the branching variables, which are then fixed
- Add extra candidate hub locations in a rolling fashion

Run time matters because need to iterate both in R&D and production

‘What-if’ with FOND

Luke Birch

Senior Fiber Planner, Planning and Design NBN Co.

First release sites - 2010

- In 2010 NBN Co. commissioned a *bake-off* between Biarri and Industry designers
- Five FSAMs were selected, representing different geo-types (inner-urban, country town…)

FSAM	Townsville	Brunswick	Minamurra	Armidale	Willunga
FOND Savings	61% reduction in new duct for local cable 10% saving on construction	1 fewer cabinet 12% reduction in new duct 11% saving on construction	Negligible cost difference Avoided disruption to main road	3 fewer cabinets	2 fewer cabinets

Each hub is a high cost item.

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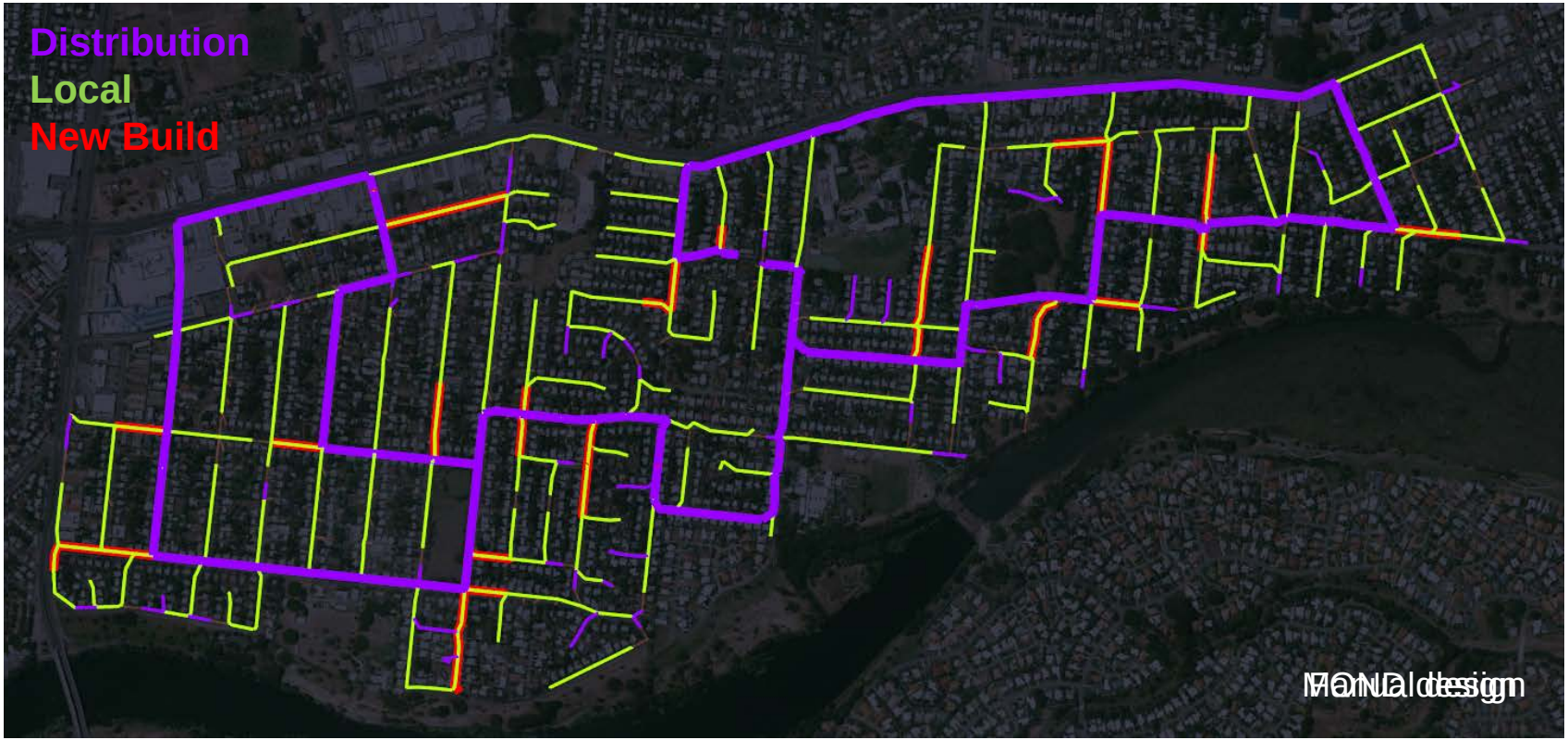
First release site: Townsville



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First release site: Townsville

Component	Incumbent Solution		Optimised Solution		Reduction		
	m	$	m	$	m	$	%
Trenched FR	9,070	997,775	8,835	971,861	235	25,850	2.59
Trenched FDA	3,285	361,438	1,255	138,150	2,030	223,300	61.7
Aerial FDA	28,190	704,770	28,583	714,576	-393	-9,825	-1.39
Total Cable	54,750	273,750	51,814	259,070	2,936	14,680	5.36
Total		**2,337,734**		**2,083,662**			**10.8**

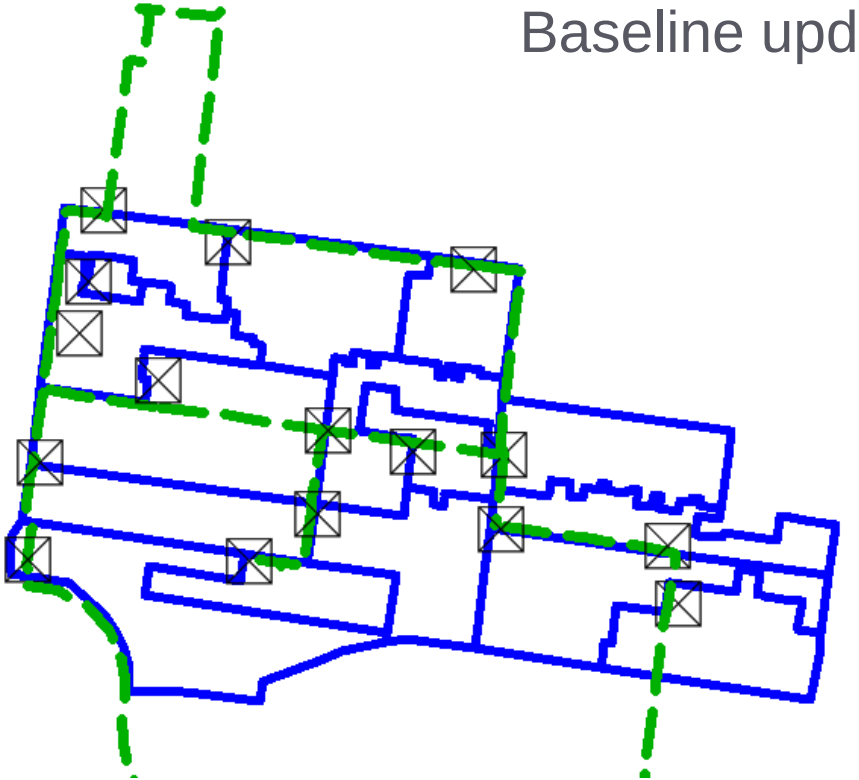
Baseline update - 2012

- In 2012 NBN Co. commissioned a second *bake-off* between Biarri and Industry designers

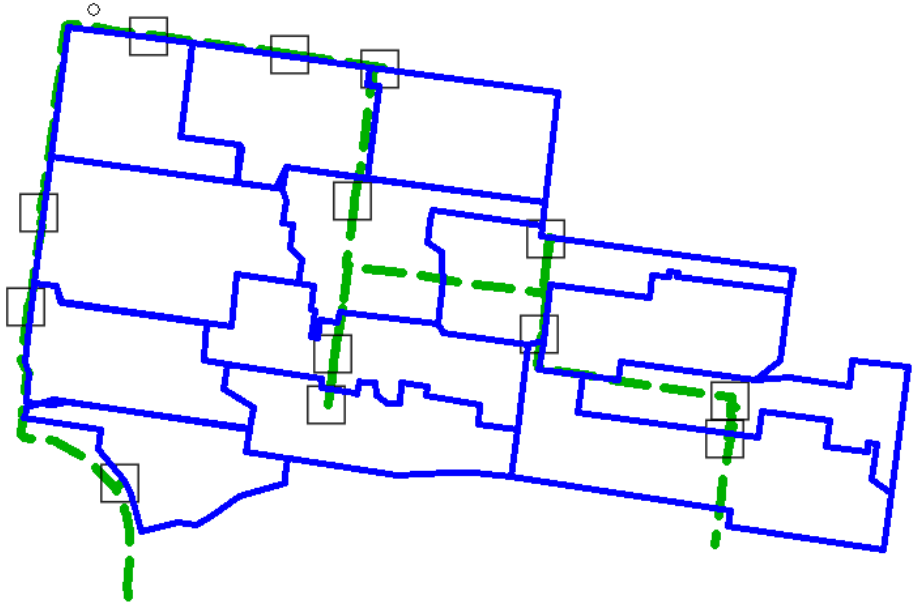
FSAM	Area BLK3	Area BLK4	Area BRU2	Area CRC9
FOND Savings	15% saving on construction Manual design used non-standard equipment	13% saving on construction Manual design used non-standard equipment	Three fewer cabinets but negligible cost difference. Manual design did not respect architecture	2% saving on construction. 4 segments of new build compared to 57 in manual design

Non compliant manual design; errors detected during analysis because manual process has no compliance enforcement.

Baseline update: Area BRU2



Manual Design, 16 Cabinets



FOND Design, 13 Cabinets

Testing alternatives

Alex Grime

Integrated Planning Manager, Planning and Design NBN Co.

A change in role for fibre planners

With existing methods

- Tactician
- Manage the detail
- Incremental: Design one street at a time
- Data entry into CAD or GIS

With Biarri FOND

- Strategist
- Control big picture
- Simultaneous: Design whole suburb
- Design review in CAD or GIS

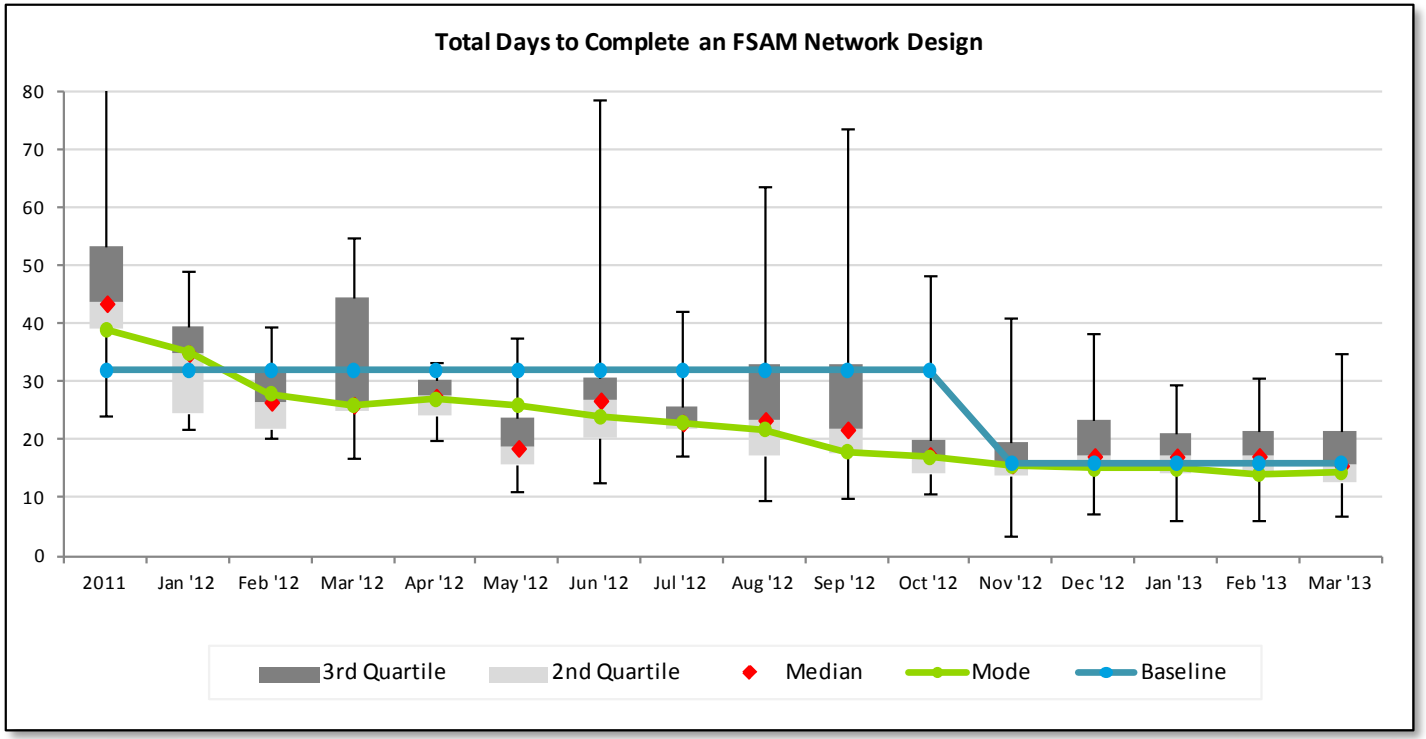
NBN view of the impact

Peter Ferris

Executive General Manager Planning and Design NBN Co.

Planning and Design – Scale production challenges

FSAM production improvement, 45 Days to 16 Days



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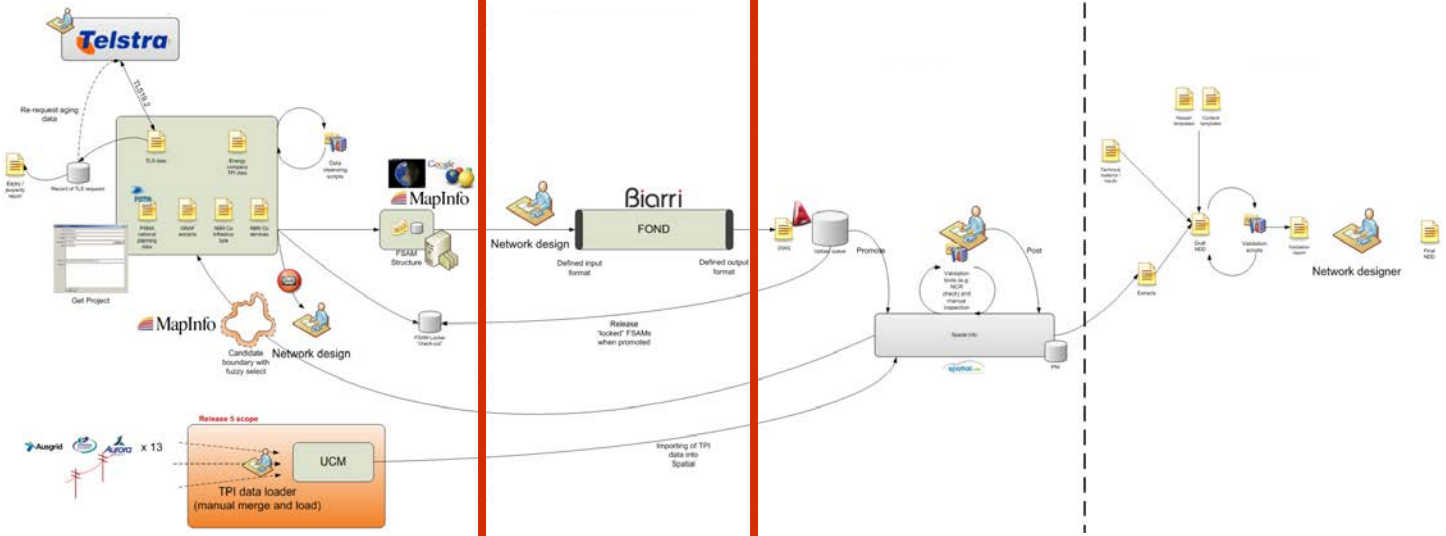
Network design cycle – 16 days average

Planning, Data Preparation & Address Cleansing

Iterative Network Design

System Data Entry and Validation

Quality Checking and Document Production



Target: 2 days

Target: 6 days

Target: 4 days

Target: 4 days

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Procedural benefits

- ✓ **Efficiency**
- ✓ **Certainty**
- ✓ **Flexibility**
- ✓ **Economical**
- ✓ **Training**

The savings (AUD)

Category	Units per FSAM	Unit Saving	Saving per FSAM
Design Time (days)	129	$500	$64,500
Construction (premises)	2500	$200	$500,000
Total Savings			

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Additional Operations Research at NBN Co

Service Footprint

Point to point

FOND Reloaded

Render

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FOND proven around the world

New Zealand

United States

Canada

Indonesia

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The Hon Malcolm Turnbull MP

Minister for Communications

Australian Government

Department of Communications

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The Wonder from Down Under