WHANGAREI
DISTRICT COUNCIL

Ensuring Effective Earthing

Measurement and Control of Earth Fault Loop Impedance at Traffic Signal Sites

Brendon Tong

Creating the ultimate living environment

WHANGAREI
DISTRICT COUNCIL

Background Scenario

- An electrician has received an electric shock from a signal pole. There are no signs of faults in the controller, with no fuses blown or circuit breakers tripped.
- What's going on?

WHANGAREI
DISTRICT COUNCIL

Pt1
General Information/FAQ

- Why do we need effective earthing?
- What's the issue?
- What are the consequences?
- How do we manage the risk and consequences?

WHANGAREI
DISTRICT COUNCIL

Why do we need effective earthing?

- We use fuses and circuit breakers to detect and disconnect overloads and faults on our traffic signal sites.
- These devices rely for operation on sufficient current passing through a fault circuit (loop) which includes the earthing system.

WHANGAREI
DISTRICT COUNCIL

What is the Issue?

- If the earthing system impedance restricts the amount of fault current, two issues arise:

1. A fault may not be disconnected at all.
2. A fault may not be disconnected quickly.

What's the consequence? Pt1

- If the fault is not disconnected at all, the exposed metalwork remains electrically alive and dangerous indefinitely (note this would normally be connected to earth and safe)

- "Slow" disconnection produces the same result until the process completes.

WHANGAREI
DISTRICT COUNCIL

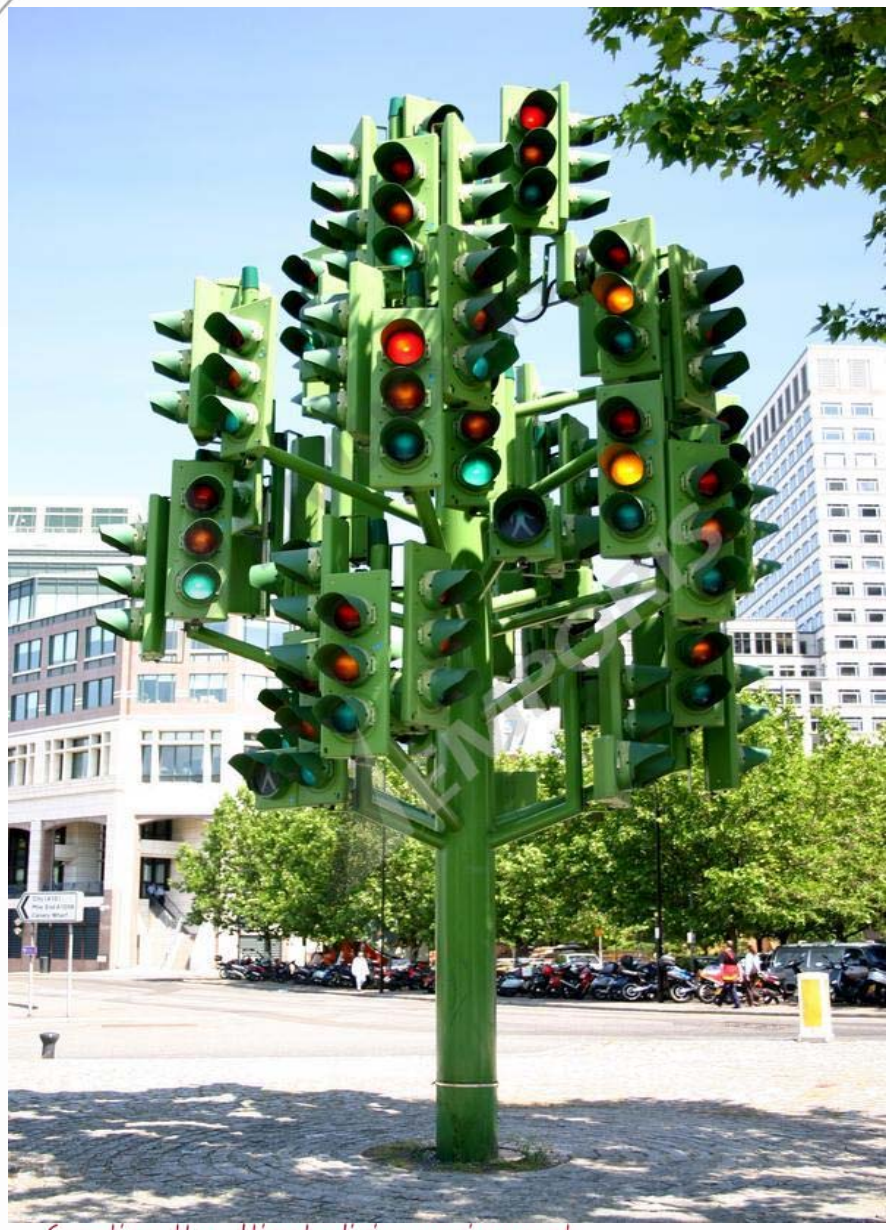
What's the consequence? Pt2

- Members of the public exposed to a risk of possible lethal electric shock.
- Liability under the Health & Safety Act.
- Non-compliance with AS/NZS3000 rules for electrical safety.

WHANGAREI
DISTRICT COUNCIL

How do we manage it?

- Carry out testing at commissioning.
- Keep records of those tests!
- Periodically test your whole network.
- Any items that don't comply go into your forward work programme.
- Above all document what is done.



Creating the ultimate living environment

Thank You
Any Questions?

WHANGAREI
DISTRICT COUNCIL

Technical Pt 2

- What testing needs to be done?
- Why earth fault loop impedance?
- How is the testing done?
- How is the information from it analysed?
- Translating this to the FWP.

WHANGAREI
DISTRICT COUNCIL

Earthing Tests

Types:

- Earth resistance test(main conductor)
- Earth resistance (bonding)
- Insulation resistance
- Earth fault loop impedance

WHANGAREI
DISTRICT COUNCIL

Earth resistance test

- This is a required test in AS/NZS 3000:2007
- It verifies that the main earth conductor has a resistance of less than 0.5Ω.

WHANGAREI
DISTRICT COUNCIL

Earthing and Bonding

- Required by AS/NZS3000:2007
- Ensures that metal items such as poles are connected by low resistance conductors and are at the same earth potential.
- Done as a pre-commissioning and routine maintenance test.

WHANGAREI
DISTRICT COUNCIL

Insulation Resistance

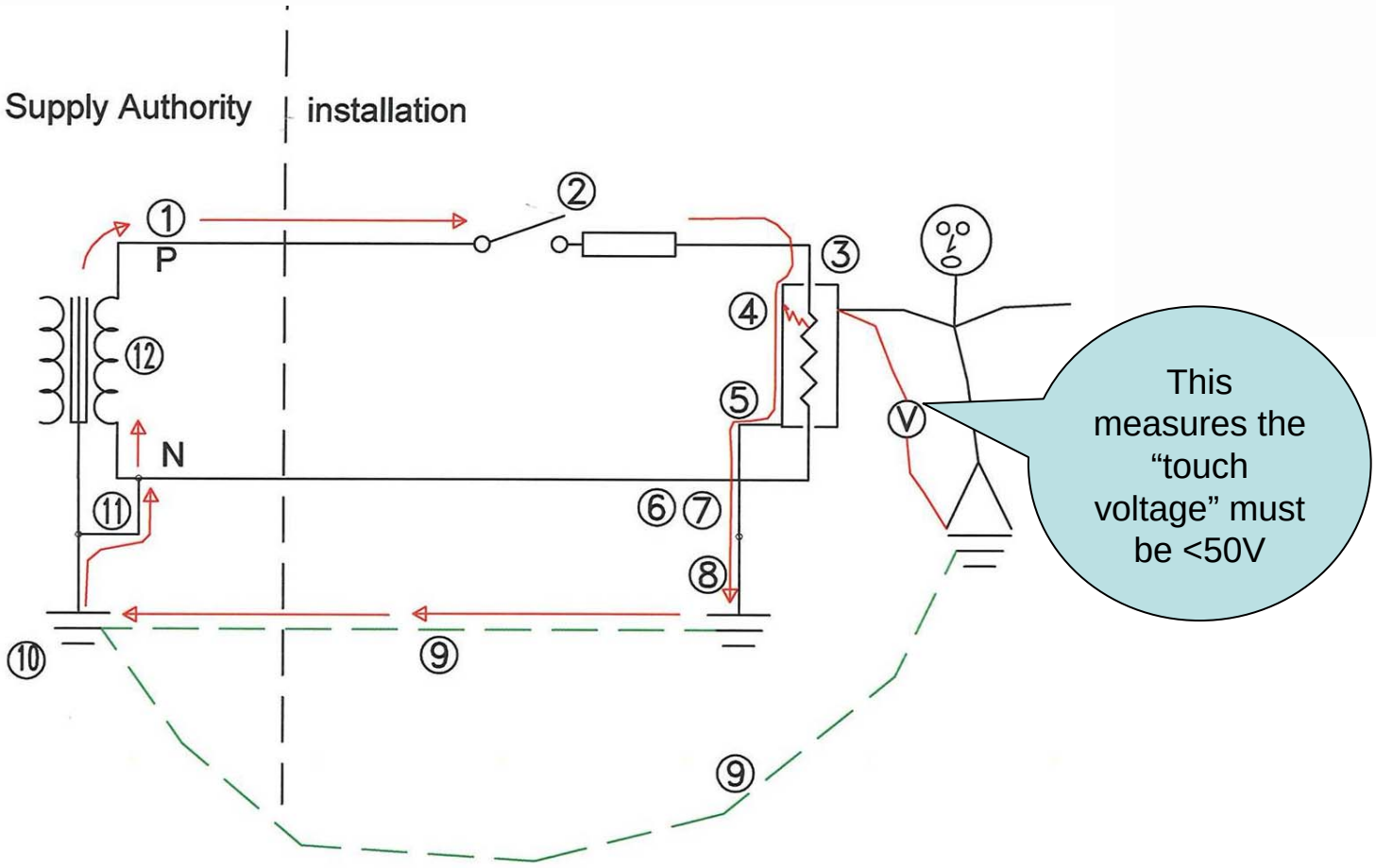
- Required by AS/NZS3000:2007
- Checks the insulation for breakdown using a 500V “megger” or similar device.
- This proves that the insulation is intact and there are no short circuits or faults to earth.
- This is normally a pre-commissioning test.

WHANGAREI
DISTRICT COUNCIL

Earth Fault Loop Impedance

- An optional test in AS/NZS 3000:2000, but now required by AS/NZS 3000:2007.
- checking the resistance of the path through the earthing system to ensure that the fault current is high enough to operate the protective gear within 400ms, and:
- the voltage on the exposed metal while the fault is present is less than 50V.

WHANGAREI
DISTRICT COUNCIL



① Service line conductor
② Protective devices
③ installation line conductors(phase)
④ Fault condition
⑤ Installation earthing conductor system
⑥ main installation earth terminal
⑦ Installation earthing conductor
⑧ Installation earth electrode(consumer earth peg)
⑨ General mass of earth
⑩ Supply Authority earth electrode
⑪ Supply Authority earthing conductor
⑫ secondary of Supply Authority transformer

Creating the ultimate living environment

WHANGAREI
DISTRICT COUNCIL

Getting Data for Testing

- Circuit breaker make, rating and type
- Controller group fuse make, rating and type.
- Setting up a data collection form.

TRAFFIC SIGNAL INSPECTION CHECKLIST

POLES

	Volts	Earth Loop	Earth Bond	Cable Insulation	Terminations
1	222	1.4	0.39		
2	221	1.9	0.25		
3	222	1.51	0.16		
4	222	1.68	0.15		
5	222	2.28	0.18		
6	221	3	0.5		
7	222	2.6	0.15		
8	222	235	1.03		
9	224	0.8			
10					
11					
12					
13					
14					
15					

CONTROLLER

Volts	239
Current	2.9
Earth Bond	.....
Peg	.....
Cabinet Earth Loop Impedence	.....
	0.2

COMMENTS

MAIN MG 63A 6KA
SOCKET GE 16A 4.5KA
CONTROLS GE 6A 4.5KA
LAMBS GE 16A 4.5KA

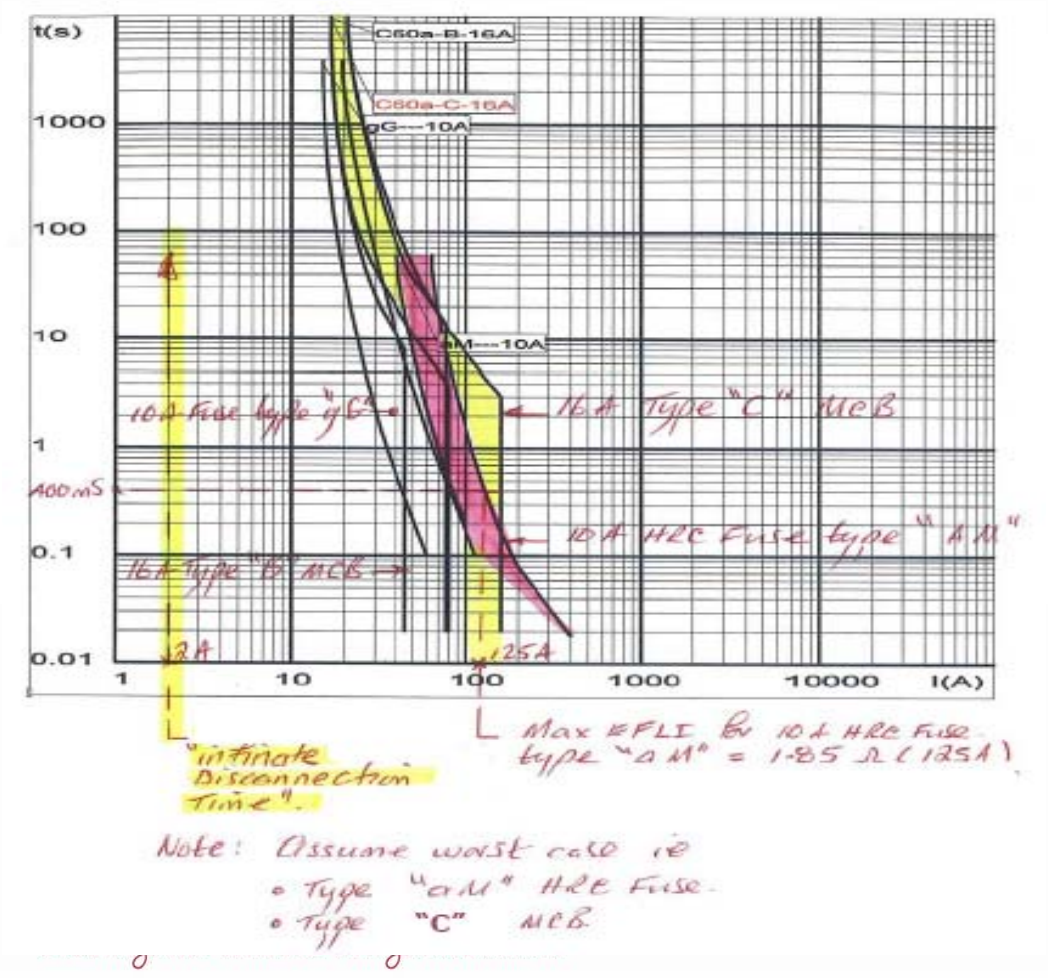
Intersection	Electrical Testing	Serviceman:
		Date:
		Time:

Creating the ultimate living environment

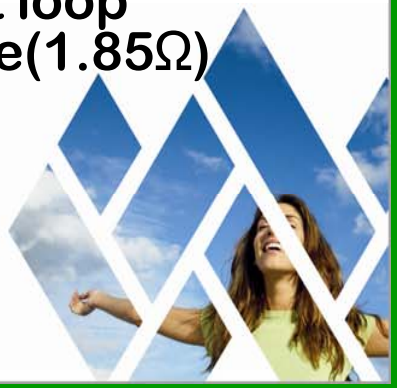
- **Data collection form for on-site testing.**
- **Values were measured at each pole and the controller.**
- **Red values are non-compliant.**

WHANGAREI
DISTRICT COUNCIL

Finding the target earth fault loop impedance value



- Apply the fuse and circuit breaker curves.
- Read off from 400ms disconnect time.
- Result is the value of fault current required(125A).
- Divide 230V by this value to get the target earth fault loop impedance(1.85Ω)



SITE \ POLE	1	2	3	4	5	6	7	8	9	10	11	12	fault count	comments/additional works
1				1.94	2.3								2	rusty terminations poles 5,8
2		1.9			2.28	3	2.6	235					5	
3						2							1	
4					2.6		1.9						2	some rusty terminations pole 12
5						2							1	
6						2							1	
7					2.3	2	2.3						3	rusty terminations poles 3,6,8
8			2.3	2.8	2.4								3	POLE NO. 8 - FIT NEW HOSE CONNECTORS POLE NO. 1 - MAST ARM TARGET BOARD BENT POLE NO. 5 - OLD CABLE, TERMINAL BOX BEEN HIT. NEEDS REPLACING POLE NO. 6 - POLE EXTENSION - OLD TERMINALS
9														
10				1.9	2.1								2	rusty terminations poles 2,6,7,8
11					2.2	2							2	
12													0	POLES NUMBERED WRONG - STARTS AT NO.2 POLE NO.6 IS CONCRETE POWER POLE POLE NO.1 NEW CABLE - NEW CONNECTORS POL NO.2 & 3 OLD CABLE - NEW CONNECTORS POLE NO.3 LOW VOLTAGE - ONLY 220V - NO TEST NO HEATER IN CONTROLLER CABINET
13	4		129	139	2.5	2							5	
14	4	4.5	5.2	6.1	6.5								5	
15				2	2.6								2	
16					2.15	3	2.3	1.9	2				5	
17				1.9	2.1								2	
18														
19								1.9					1	
20														
21													0	rusty terminations pole 8 in Mk2 pole top
22													0	POLE NO.5 MAST ARM BOX DAMAGED

	>4 ohms - high priority
	2-4 ohms - medium priority
	<2 ohms - general maintenance

Note that data has yet to be supplied for Site 9(under construction), Site 18 and Site 20

WHANGAREI
DISTRICT COUNCIL

Prioritising non-complying results

- WDC results had a target value of 1.85Ω.
- >4Ω was defined as high priority (immediate action).
- 2-4Ω medium priority (as soon as possible)
- 1.85-2Ω general maintenance.

WHANGAREI
DISTRICT COUNCIL

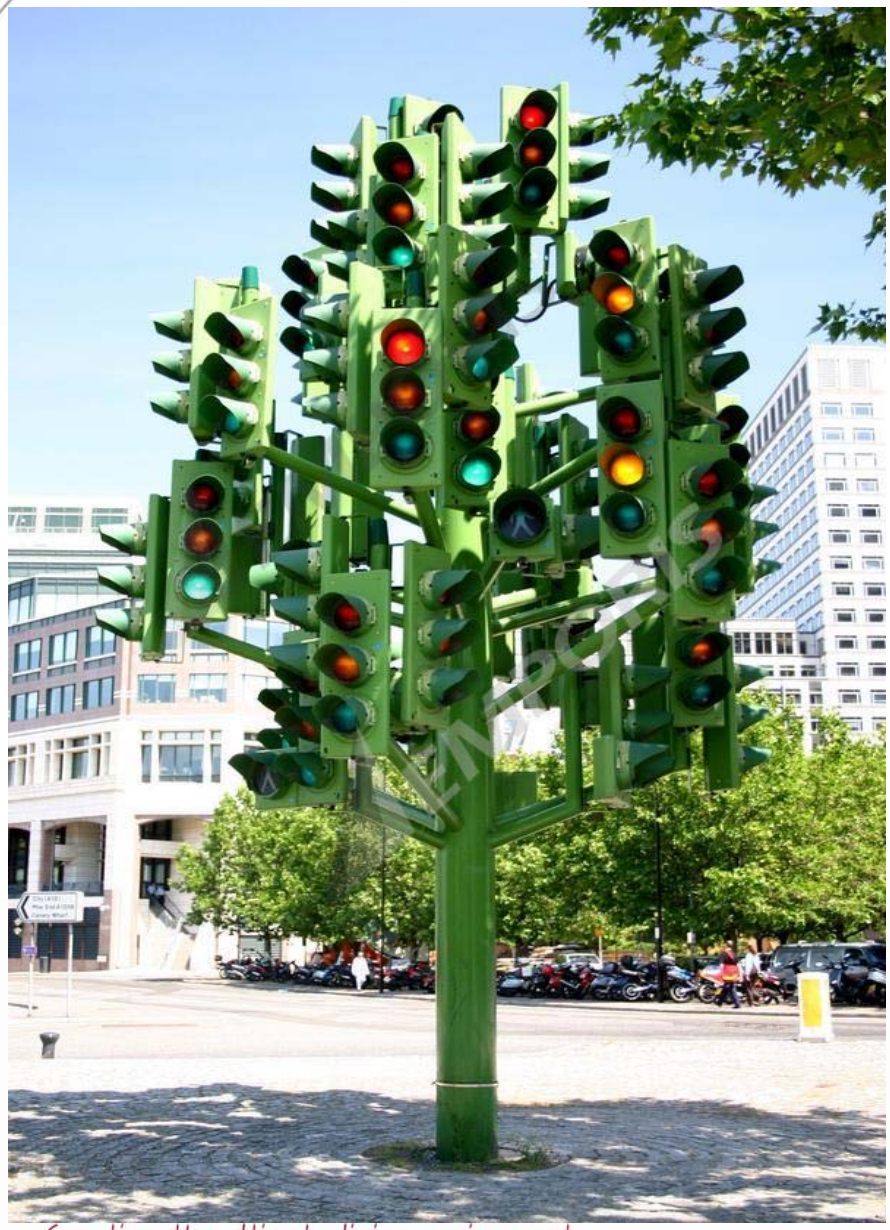
Comments on priority

- For a 16A type C circuit breaker and 400ms disconnect time the maximum allowed is 1.92Ω(table 3.1, NZS3017:2007)
- For a 16A type B circuit breaker(same conditions) it is 3.59Ω

WHANGAREI
DISTRICT COUNCIL

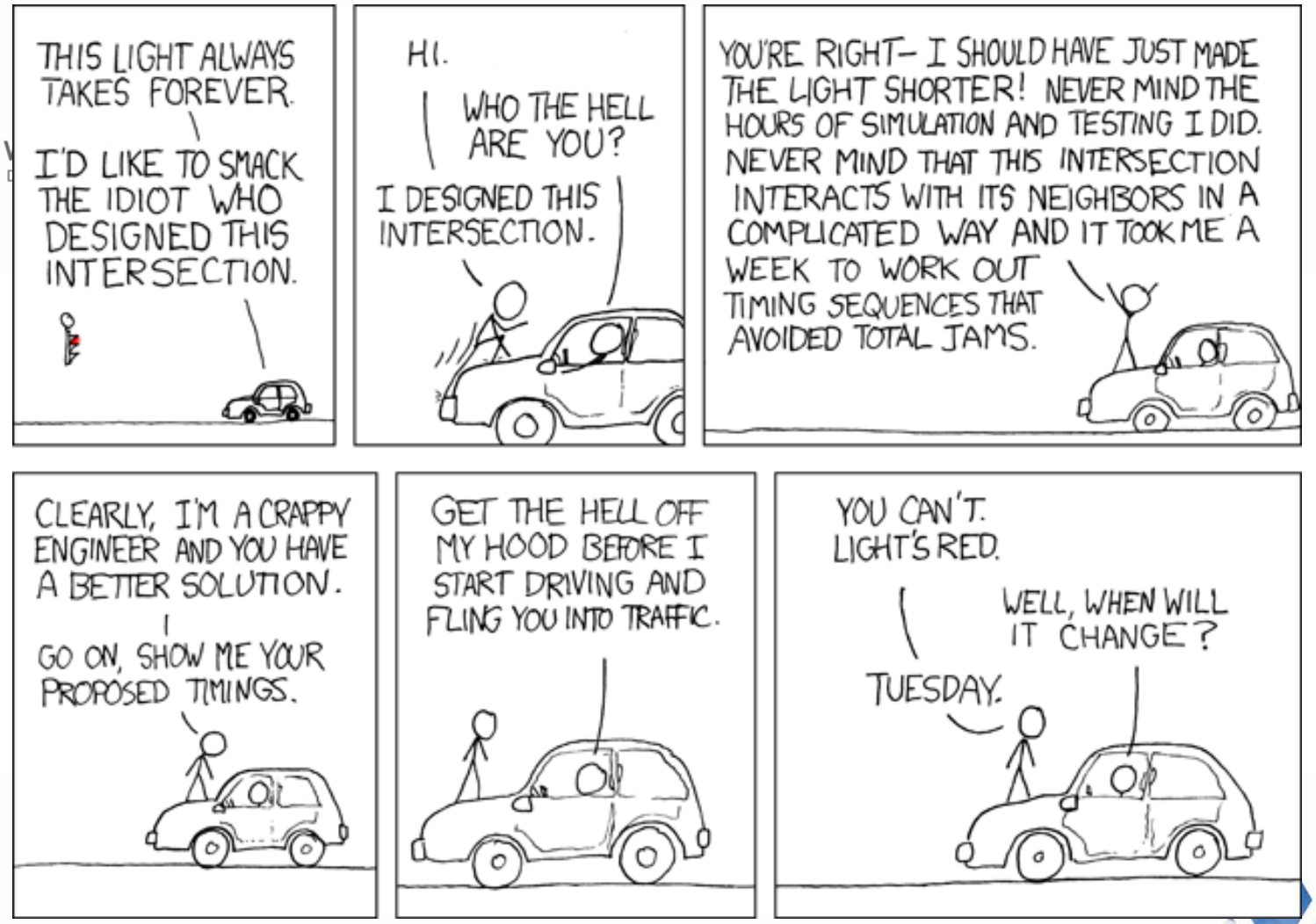
Further work

- Review the National Traffic Signal (NTTS) Specification in the light of this study
- Conduct a general review of the NTTS for compliance with AS/NZS 3000:2007



Creating the ultimate living environment

Thank You
Any Questions?


THIS LIGHT ALWAYS TAKES FOREVER.
I'D LIKE TO SMACK THE IDIOT WHO DESIGNED THIS INTERSECTION.
HI.
WHO THE HELL ARE YOU?
I DESIGNED THIS INTERSECTION.
YOU'RE RIGHT— I SHOULD HAVE JUST MADE THE LIGHT SHORTER! NEVER MIND THE HOURS OF SIMULATION AND TESTING I DID. NEVER MIND THAT THIS INTERSECTION INTERACTS WITH ITS NEIGHBORS IN A COMPLICATED WAY AND IT TOOK ME A WEEK TO WORK OUT TIMING SEQUENCES THAT AVOIDED TOTAL JAMS.
CLEARLY, I'M A CRAPPY ENGINEER AND YOU HAVE A BETTER SOLUTION.
GO ON, SHOW ME YOUR PROPOSED TIMINGS.
GET THE HELL OFF MY HOOD BEFORE I START DRIVING AND FLING YOU INTO TRAFFIC.
YOU CAN'T. LIGHT'S RED.
WELL, WHEN WILL IT CHANGE?
TUESDAY.

www.xkcd.com