SATURN

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What a Noise!

- Assignment, Variability and Fixed Cost Flow 101

User Group Meeting

Thursday 16th November 2017

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Structure

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- Fixed Cost Flow Function 101
  - What they are & how they work
  - How they can help with Scheme Appraisal
- Variability within the SATURN Assignment
  - How it arises
  - Possible impacts on Scheme Appraisal

Fixed Cost Flow Function 101

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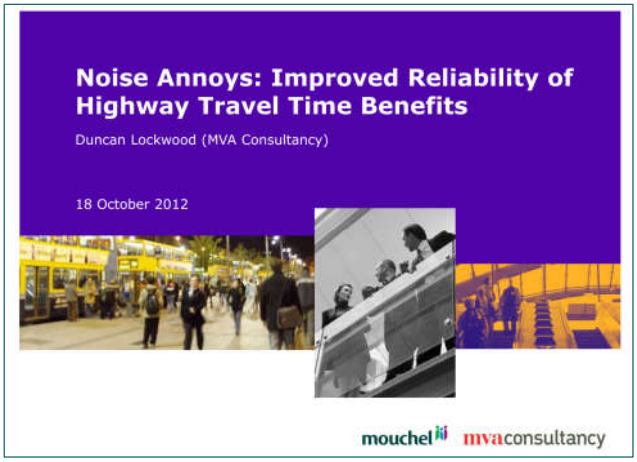
Background

- The Long View

- Developed in 2012
  - HA Collaboration Project for M60MMS
- HERTMs facing similar challenges
  - Not a new problem!
- 2012 UGM presentation
  - Excellent content …
  - … and now adding to



Identifying the Problem (1)

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- Benefits should be:
  - plausible (size and location);
  - stable (or change as expected); and
  - measurable compared to noise
- We tested a range of scheme options and found that benefits were:
  - inconsistent between options;
  - inconsistent between time periods for the same option;
  - did not always change as expected;
  - and we had no way to measure the scale of the benefits against model noise (TAG 10.9.24 only partly addresses this)

Current Issue

Identifying the Problem (2)

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- Further analysis showed:
  - changes in flows, delays and speeds from implementing the scheme in areas where they were not plausible;
  - and therefore implied benefits (or disbenefits) at nodes where the scheme would not be expected to have a measurable effect;
  - changes in flows, delays and speeds between the (n) and (n+1) assignment of the same scenario
  - and therefore implied benefits (or disbenefits) between the (n) and (n+1) assignment of the same scenario

Variability in the assignment matching scheme benefits

Quantifying the noise

Benefits using the (n) or (n+1) iteration				
		Benefits	Disbenefits	Net Benefits
DoMin vs DoSome	(n) iteraton	351	-281	69
	(n+1) iteration	390	-333	56
Implied Benefits between (n) and (n+1) iteration				
(n) vs (n+1)	DoMin	277	-261	16
	DoSome	266	-236	29

Scenario 'Difference'

Assignment Noise

- Implied benefits (and disbenefits) from running an extra assignment iteration are of a similar scale to the scheme benefits

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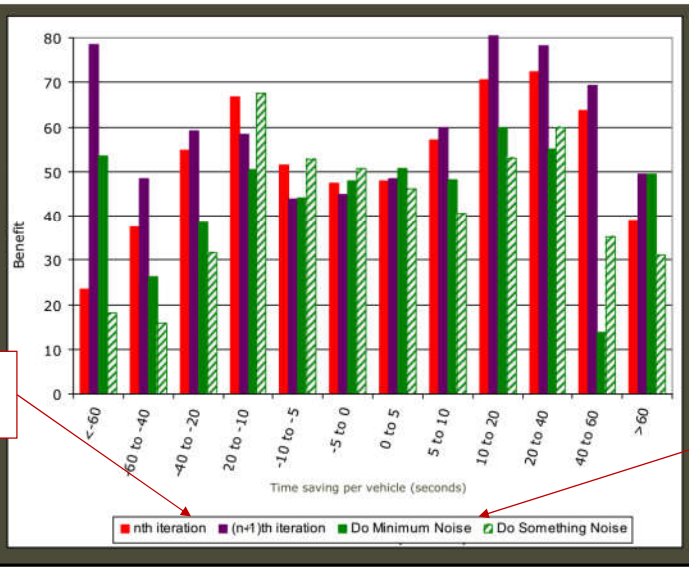
Visualising the scale of the noise compared to the benefits



Scheme Difference

Assignment Differences

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The Solution
Step 1: Improved Convergence

- Use %GAP as the stopping criteria
- Increase NITS, NITS_M and NITA_M

	Weaker convergence		Tighter convergence	
	10.8.22		10.9.24	
	DoMin	DoSome	DoMin	DoSome
Percentage of links with flow change < 1%	99.7%	99.5%	99.1%	99.3%
	99.7%	99.8%	99.2%	99.3%
	99.8%	99.8%	99.3%	99.4%
	99.7%	99.8%	98.9%	99.5%
%GAP	0.14%	0.16%	0.01%	0.01%
Assignment Delta / number of iterations	0.18 / 2	0.15 / 2	0.01 / 22	0.01 / 30
Loops	17	16	120	120
Run time (minutes)	50	49	117	111

Outside TAG M3-1 Table 4 Recommendation

Aim for highest practicable level of convergence

Looks a bit slow now!

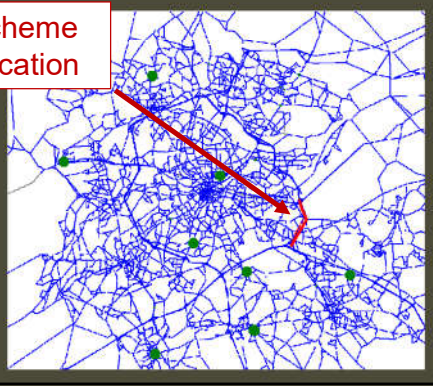
Improved Convergence Results

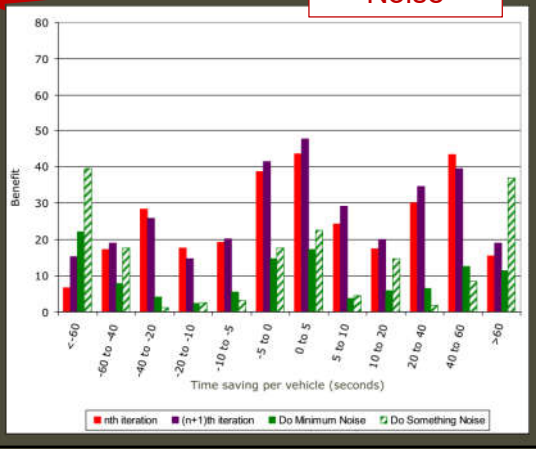
Scenario 'Difference'

Assignment 'Noise'

Benefits using the (n) or (n+1) iteration				
		Benefits	Disbenefits	Net Benefits
DoMin vs DoSome	(n) iteraton	174	-127	47
	(n+1) iteration	189	-136	53
Implied Benefits between (n) and (n+1) iteration				
(n) vs (n+1)	DoMin	57	-56	1
	DoSome	89	-81	7

Scheme Location





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Area of Influence for FCF

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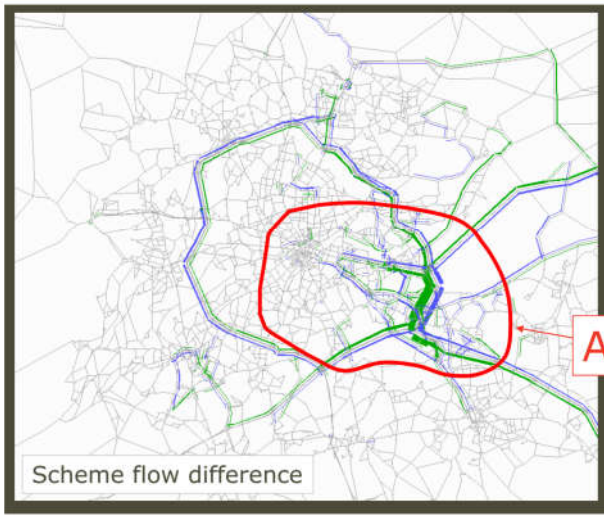

FCF-based simulation outside

Standard simulation inside

mouchel mvaconsultancy

FCF Option 5 Results

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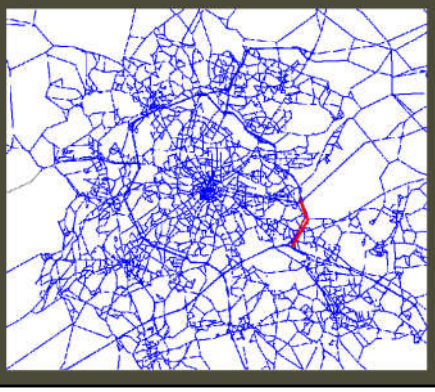
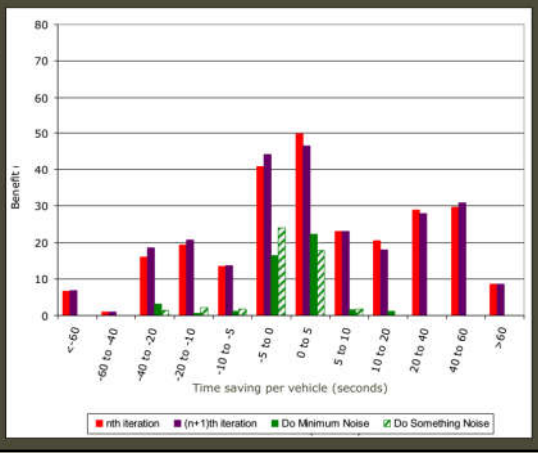
Benefits using the (n) or (n+1) iteration				
		Benefits	Disbenefits	Net Benefits
DoMin vs DoSome	(n) iteraton	160	-97	63
	(n+1) iteration	155	-105	50
Implied Benefits between (n) and (n+1) iteration				
(n) vs (n+1)	DoMin	25	-21	4
	DoSome	20	-29	-9

With FCF, assignment noise significantly reduced





Weaker Convergence

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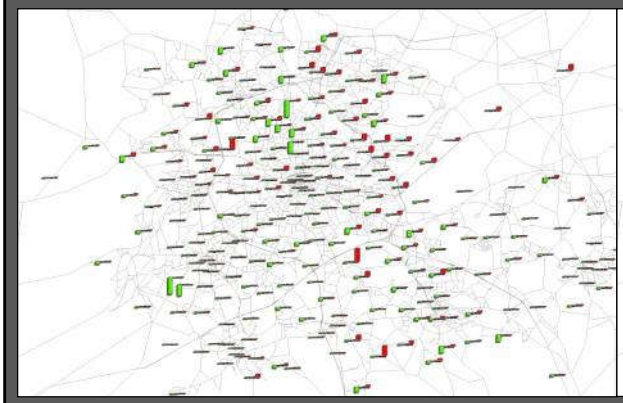
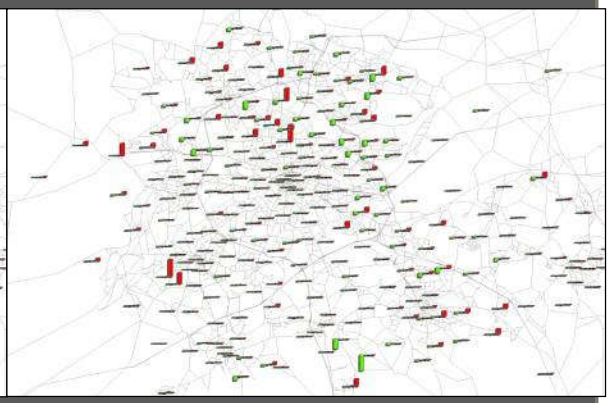
Benefits



Noise



Tighter Convergence

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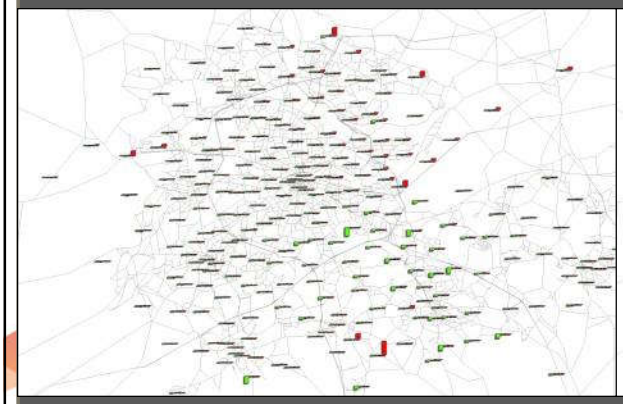
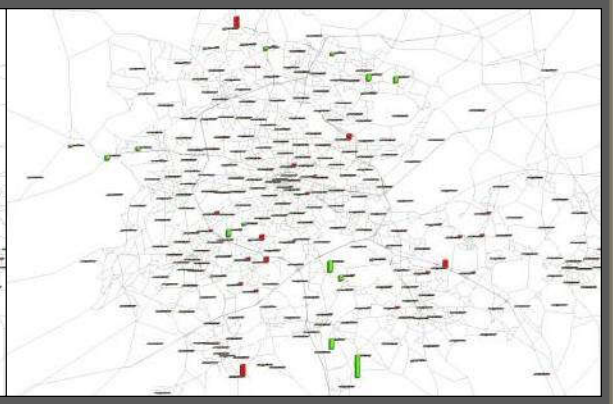
Benefits



Noise



With FCF

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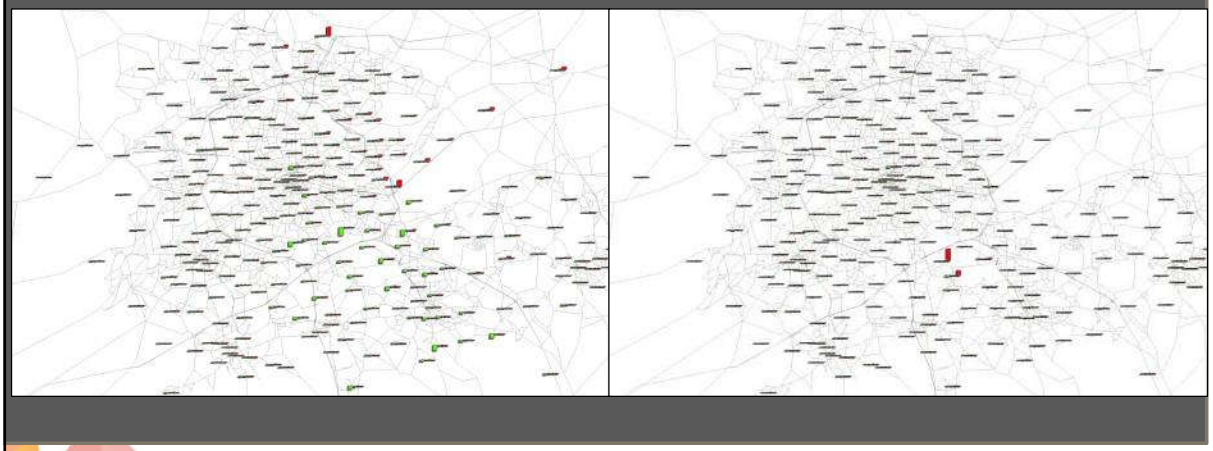
Benefits	Noise



How does the Fixed Cost Flow function work?

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- Small modification to the internal junction simulation calculations

Junction simulation modelling enables delays per turn to take account of:	Std. Node	FCF Node	Buffer Node
Gap acceptance for give-ways & stop lines	✓	✓	×
Individual turn saturation flows	✓	✓	×
Lane / turn allocations	✓	✓	×
Signal timings and offsets	✓	✓	×
Blocking back between junctions	✓	✓	×
Downstream flow metering arising from upstream capacity constraints	✓	✓	×
Platooning effects	✓	✓	×

A Simulated Junction (i) - Representing each individual turn

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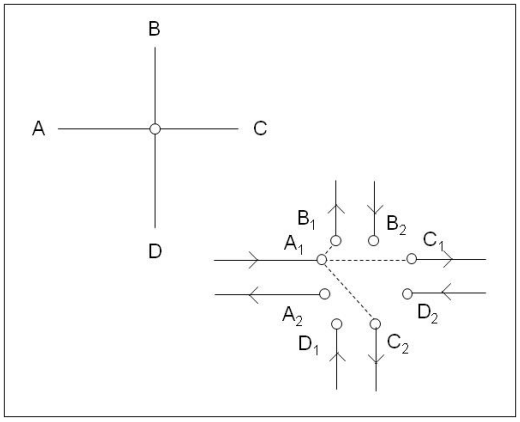
- Internally, each junction is expanded into a series of one-way links for each turn generating the 'Assignment network'
- A four-arm junction gives
  - Assignment nodes
    - 4 inbound (X_1)
    - 4 outbound (X_2)
  - Assignment links
    - 12 links

  (assuming no U-turns)

  (Hence link A-B, turn A-B-C)



A Simulated Junction (ii) – Flow-Delay Curves

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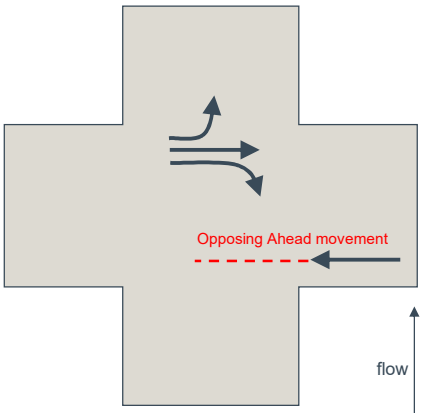
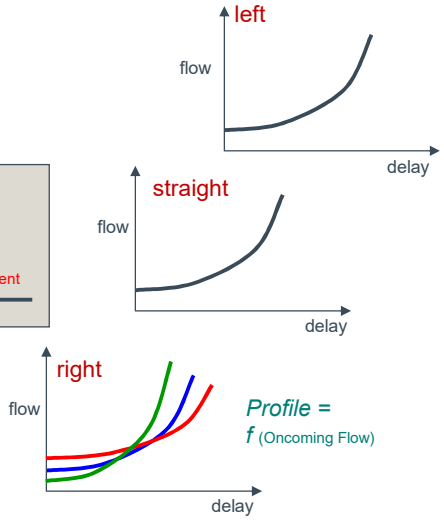
Based on:

- the junction characteristics &
- vehicular interactions

Simulation estimates a bespoke flow-delay curve for each individual assignment turn

- Iterative process





A Simulated Junction (iii) – Fixed Cost Flow Function

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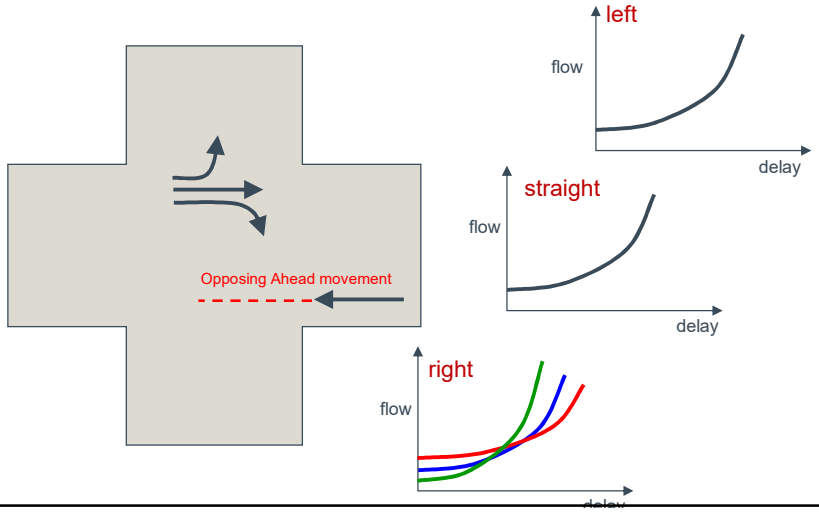

If a node is flagged as FCF-node:

- 'Shape' of the flow-delay curve for each turn is not estimated
- But taken from a previous assignment unchanged
- Hence: a 'Fixed Cost Flow' function

FCF – Advantages / Disadvantages

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Advantages

- Well-established technique
- Retains the benefits of simulation with higher convergence & reduce runtimes
- Significantly reduces convergence noise between DM (say) and DS (say) in peripheral areas
- Same (converged) assignments using simulation and FCF simulation should be similar
- Fully compatible with existing Variable Demand Model – no revisions
- Proven to reduce 'noise' in the economic analysis
- Automated process once set-up

Disadvantages

- Not much from a technical point of view
  - provided the donor (say DM) simulation is considered sound
- Practically, requires an extra DM run with FCF for each scenario

Variability with the SATURN Assignment

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SATURN Assignment 101 - Quick recap

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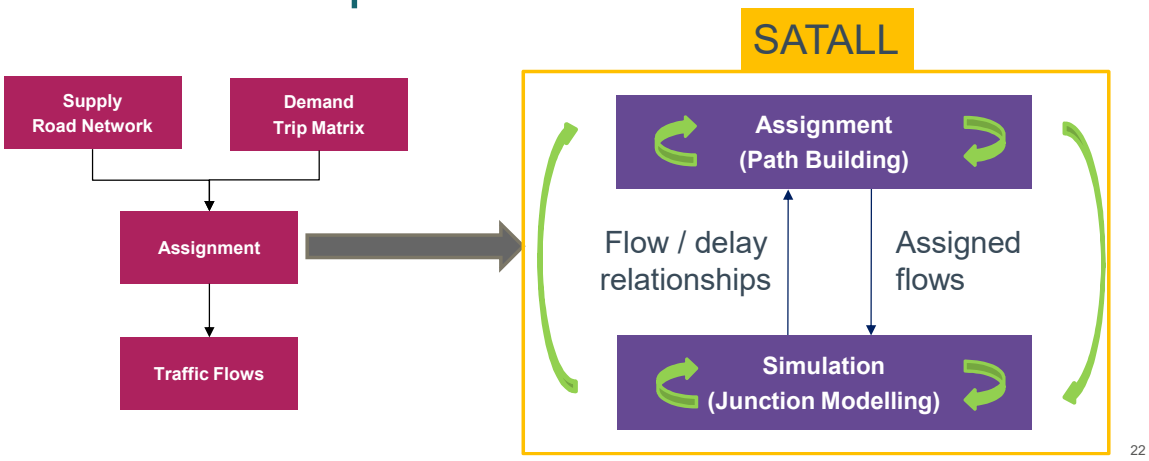

Assignment Process

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Loop	Assignment	Simulation	Cumulative (AON) Paths
1	20 Path Builds	20 Simulation Iterations	0 + 20 = 20
2	20 Path Builds	20 Simulation Iterations	20 + 20 = 40
3	20 Path Builds	20 Simulation Iterations	40 + 20 = 60
…			
n	20 Path Builds	20 Simulation Iterations	= n * 20

Iterate until Stability (%Flow) & Proximity (%GAP) targets are satisfied
- See Table 1 in LPT file

Convergence Profile
- LPT Table 1 plotted

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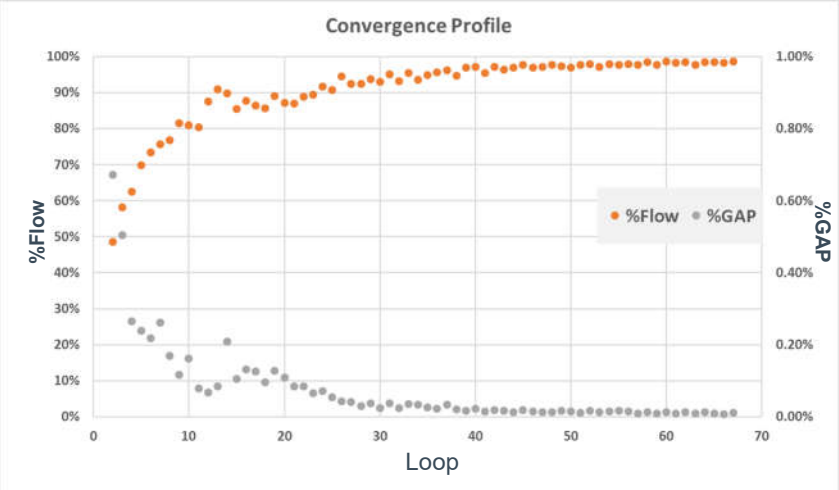

Note:

- Output at end of each loop may be a final converged solution
- NISTOP = 4 but why not 5 instead?
- Each solution will be different
- Variation in each assignment!

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Convergence Profile
- LPT Table 2 Assignment Hours

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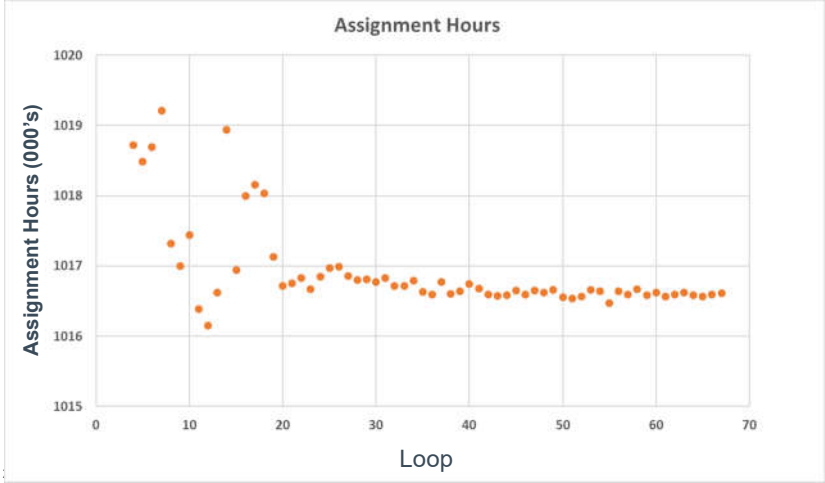

Note:

- As %GAP reduces, variation between successive loops will reduce
- Perfect convergence = identical
- Scheme Appraisal uses the time skims
- Difference of

DM v DS >> DM (n+1) v DM (n)

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Secondary Analysis
- The Role of SAVEIT

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- Cost data stored in the UFC file for secondary analysis
- Recreates assignment using either :
  - the original full set of paths used or a SAVEIT approximation
- By default, UFC109=T & NITA_C=256 so
  - full set saved unless cumulative path builds > 256
  - otherwise SAVEIT used - maximum no. of path builds set by NITA_S
- Value of NITA_S is very important
  - If too small (e.g. 25!) then too few paths used in SAVEIT approximation
  - Likely that very poor Wardrop solution (Approximation %GAP >> Final %GAP)
  - Use v11.4 default: NITA_S=256

!!!Don't dump DAT Files from using P1X!!!

Impact on TUBA Scheme Appraisal - Illustrative Example

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- Two With & Without Scheme Scenarios, 60 year appraisal

	Ref Case	Run 1	Run 2	Run 3	Run 4	Run 5
NITA_S	256	25	99	256	256	256
NISTOP	4	4	4	5	4	4
RSTOP	98.5%	98.5%	98.5%	98.5%	97.5%	94.5%
AM - %Flow	98.9%	98.9%	98.9%	98.5%	98.0%	96.7%
AM - %GAP (Main)	0.009%	0.009%	0.009%	0.008%	0.010%	0.036%
AM - %GAP (SAVEIT)	0.010%	0.164%	0.016%	0.008%	0.012%	0.036%
PVB (Index)	100	85 !!!	95	95	95	95

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Questions?

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