Volunteer Network of Professionals Working Together to Support, Promote, and Improve Best Practices in the Application of Traffic Simulation and Capacity Analysis

Meeting Agenda

- Welcome and SimCap Updates
- Simulation in the ‘70s and Beyond – An Insider’s Retrospective
- Open Discussion

ITE SimCap Committee

- Held committee meeting (Jan. 12)
  - Materials posted to SimCap e-Community
- ITE website is UP!
- Upcoming May webinar
  - Featuring simulation case studies
  - Presenters needed!
- Upcoming session at 2021 ITE Annual Meeting
  - Traffic Analysis, Modeling, and Simulation Cornucopia

Joint Simulation Subcommittee
ACP80(1)

Sponsor Committees:
ACP20: Freeway Operations
ACP25: Traffic Signal Systems
ACP40: Highway Capacity and Quality of Service
ACP50: Traffic Flow Theory and Characteristics
ACP55: Traffic Control Devices
ACP80: Traffic Simulation
AEP40: Transportation Network Modeling
AMS10: Air Quality and Greenhouse Gas Mitigation

Co-Chairs:
Christopher Melson (LTRC)
John Shaw (InTranS)

TRB
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

SimSub Goals

- Develop, maintain, or otherwise leverage existing, mechanism(s) to collect user needs and related input
- Recommend actions and venue to address user needs
- Develop, maintain, host, or otherwise contribute to existing, “living” library of reference material
- Provide forum for information exchange and foster joint efforts
- Maintain comprehensive liaison structure

SimSub Goals

- Develop, maintain, or otherwise leverage existing, mechanism(s) to collect user needs and related input
- Recommend actions and venue to address user needs

User Needs Task Group

- Develop, maintain, host, or otherwise contribute to existing, "living" library of reference material

Resources Task Group

- Provide forum for information exchange and foster joint efforts
- Maintain comprehensive liaison structure

Liaison/Outreach Task Group

TRB Joint Simulation Subcommittee (SimSub)

- Held Annual Meeting (Jan. 5)
  - Meeting Minutes in chat
- Held Spring Liaison Meeting (Mar. 5)
  - Defined goals, task groups
  - Meeting Minutes coming soon
  - Volunteers needed!
- Subscribe to e-mail listserv

Local Updates

- FHWA Louisiana Division Office
- LaDOTD
- Louisiana MPOs/Planning Commissions
- Other

Contact Information

Christopher Melson
LTAP Program Manager
(225) 767-9118
cmelson1@lsu.edu

https://simcap.eng.lsu.edu/

GPI

Mark Yedlin
Greenman-Pedersen, Inc.

Simulation in the ‘70s and Beyond – An Insider’s Retrospective

Simulation in the ‘70s and Beyond

An Insider’s Retrospective

Presented to: SimCap Louisiana by Mark Yedlin (myedlin@gpinet.com)

Date: March 11, 2021

GPI

Engineering | Design | Planning | Construction Management

Agenda

- **Introduction/Background**
- **Computing in the 1970s**
- **Traffic simulation modeling in 1970s and 1980s**
  - What was it like?
  - What was available?
  - How did the era shape simulation models and modeling?
- **Qualities to succeed back then**
- **Lessons for today**

Background

FHWA Office of Operations - History of CORSIM (2/1/2017)

https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol4/app_a.htm

"CORSIM has a long history reaching back to the 1970s and mainframe computers. Many fixes, improvements, and enhancements have been made since the original coding but the basic theory of CORSIM still retains its roots.

… surface streets are modeled internally in CORSIM using code that came from NETSIM (abbreviated for NETwork SIMulation). NETSIM was originally developed as the "Urban Traffic Control System" (UTCS-1) in the early 1970s."

Background

- **George List presented history of SimSub at TRB Joint Simulation Subcommittee Meeting on January 5, 2021**

- **Recognized Edward Lieberman as first recipient of a Lifetime Achievement award in Simulation Modeling in 2007**

About Presenter and Ed's Modeling Team

- **Ed hired Mark in 1977 to join his team (already 5 years old)**
- **Other members were Reuben Goldblatt, and Barbara Andrews**
- **Under contracts with FHWA's Offices of Research and Implementation team:**
  - Developed original UTCS-1, INTRAS, NETSIM, CORFLO and ROADSIM code
  - Provided nationwide support and training for traffic simulation models until FHWA's role in sponsoring and maintaining models changed
- **A major force for modeling at FHWA in 1970s was Guido Radelat!**

Computing in the 1970s

- **Era of Mainframe Computers**
- **IBM and the 5 dwarfs (“the BUNCH”)**
  - **B**urroughs
  - **U**nivac
  - **N**CR
  - **C**ontrol Data Corporation (CDC)
  - **H**oneywell
- **Each had their own OS and Fortran**
- **Major modelers in the 1970s did not use IBM**
- **NETSIM had to work on *all* these computers!**

Computing in the 1970s

- **Mainframe computer time expensive and charged by the hour**
  - $1,800 to $2,100/hour for CDC 7600 supercomputer in the 1970s
  - $8,000 to $9,400/hour today
- **RAM was a limited precious resource**
  - Numbers stored in either 16 or 32-bit chunks of memory (half or full words)

Storing Numbers

16 Bit “Half-word”

Sign Bit

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Bit, n
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1	Bit value, $2^{(n-1)}$

$$4{,}680 = 4096 + 512 + 64 + 8$$

Memory and Bit Packing

- **For each simulated vehicle, software needed to know its:**

Link	Position	Lane
Speed	Acceleration	Catgory (Car, Truck, Bus, HOV)
Driver Personality	Desired speed	Type (of car, bus, etc.)
Leader	Follower	State (moving, stopped, in-queue)
Next turn	etc.	etc.

- **Information stored in memory in 32-bit full word or 16-bit half word arrays**
  - Speed(1), Speed(2), ….Speed(1,800) for 1,800 vehicles
  - Accel(1), Accel(2),….Accel(1,800)
  - Too many variables and not enough RAM to store this way!
  - Needed to pack **multiple** pieces of information in a single full or half word!

Bit Packing

16 Bit Half-word, SPDLN(IV)

Sign Bit

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Bit, n
	8	4	2	1	1	4	2	1								
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1	Bit value, $2^{(n-1)}$
	Accel (fpss) Bits 12-15, Max, 15				Decel if 1	Lane Bits 8-10, Max =7			Vehicle speed (fps) Bits 1-7, Max = 127							

- **Saved memory but increased computational cost**
- **Tricky to debug if a number was stored that was too big for its bits!**

Explosion in Computing Speeds

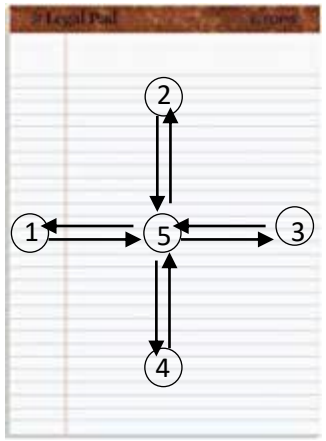
- **FLOPS – Floating Point Operations per Second**

Year	Computer	Speed	Ratio to CDC 7600
1969	CDC 7600 (First supercomputer)	40 megaflops ($40*10^6$)	1
2017	Intel Core i9 chip (for high end PCs)	1 teraflop ($1*10^{12}$)	25,000
2018	Summit supercomputer	122 petaflops ($122*10^{15}$)	3,050,000,000

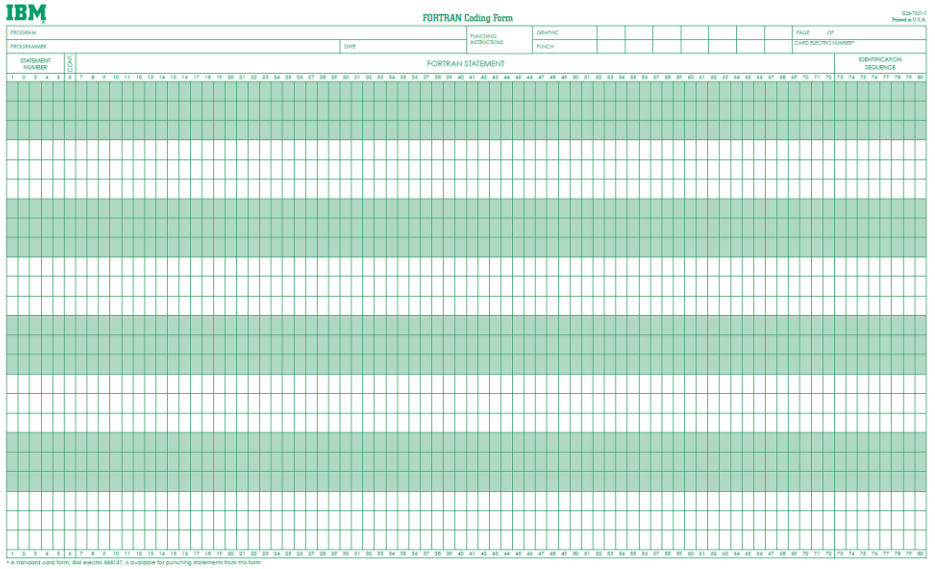
- **Mid-1970s computing cost in today's terms: $8,000 for 1 hour on a machine 25,000 times slower than a current high-end PC**

What did you need for traffic simulation modeling?

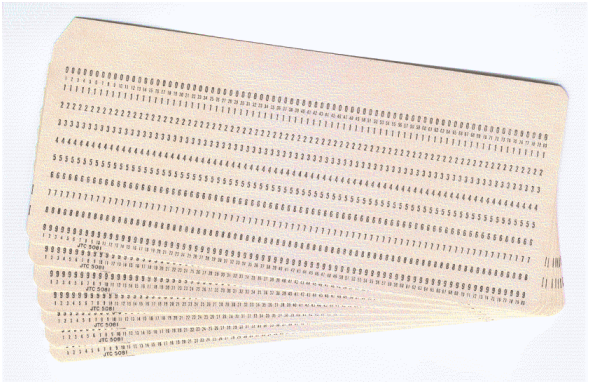
Pencil



Paper, Network sketch

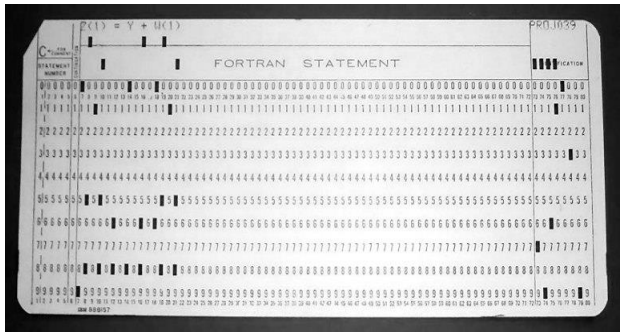


80 Column Coding Form



Blank
Punch Cards

Keypunch Machine



Punched Cards

Card Reader

What did you need for traffic simulation modeling?

Large Mainframe Computer

CDC 7600 Supercomputer at LLNL

Logistics

- Computer at Brookhaven National Laboratory (BNL) was 35 miles from the office and 50 miles from home
- Staff went to BNL once or twice a week
- Coding forms done on Monday might not be keypunched, run and results returned before Thursday or Friday
- 3 to 4 days to learn of syntax or other minor error was unacceptable!
- Luxury of time to think, review and “play” computer
- Identify errors in model code and inputs in advance
- Buddy system to review all coding forms and find errors before forms brought to BNL
- Try to make logic fail!

Basic Card Types

```
INPUT FILE NAME: C:\TSIS6 Projects\Corsm1 Example\corsm1.trf
RUN DATE       : 12/22/06


TTTTTTTTTTT  RRRRRRRRR      AAAAAAA    FFFFFFFFFFF
TTTTTTTTTTT  RRRRRRRRRR    AAAAAAAAA   FFFFFFFFFFF
TTTTTTTTTTT  RRRRRRRRRRR  AAAAAAAAAAA  FFFFFFFFFFF
    TTT      RRR     RRR  AAA     AAA  FFF
    TTT      RRR     RRR  AAA     AAA  FFF
    TTT      RRRRRRRRRRR  AAAAAAAAAAA  FFFFFFF
    TTT      RRRRRRRRRR   AAAAAAAAAAA  FFFFFFF
    TTT      RRR RRR      AAA     AAA  FFF
    TTT      RRR  RRR     AAA     AAA  FFF
    TTT      RRR   RRR    AAA     AAA  FFF
    TTT      RRR    RRR   AAA     AAA  FFF
    TTT      RRR     RRR  AAA     AAA  FFF


                VERSION 6.0
                RELEASE DATE MARCH 2006

                TRAF SIMULATION MODEL

                    DEVELOPED FOR

              U. S. DEPARTMENT OF TRANSPORTATION
                FEDERAL HIGHWAY ADMINISTRATION
          FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY
```

Basic Card Types

```
1                                    CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    1 :SAMPLE TEST DATASET FOR FHWA CORSIM                                          0
    7 :TRAF USER                              5  141999FHWA                    0   1
    8 :       1   0      20     7981 0000  0              3 730        7781    7581   2
    9 : 900                                                                        3
   10 :                  60                                                        4
   11 :   0       0   0   0   0   0   0   0   0   0   1                            5
   12 :  11 711 540         3     01000         8011              25  22  35  0     11
   13 :  29  31 530         2     0100          8031              20  18  30  0     11
   14 :  15 115 420         2     0100          8015              25  22  30  0     11
   15 :  16  17 550         2     0100          8017              25  22  30  0     11
  101 :  11 711   0 100   0   0                                                     21
  102 :  29  31   0 100   0   0                                                     21
  103 :  15 115   0 100   0   0                                                     21
  104 :  16  17   0 100   0   0                                                     21
  190 :  10  25  11  14 710          22   2   1  22   2   1                        35
  191 :  11  10 711  12  15  10      37   3   1  43   3   1   9   2   1            35
  192 :  12  10 122  16  11          27   2   1  10   2   1   4   2   1            35
  221 :  11 9292 0202 2222 2121 2020 2222 4343 0000 2222                           36
  224 :  14 1292 0202 2222 2121 2020 2222 4343 0000 2222                           36
  225 :  16 9292 0202 2222 2121 2020 2222 4343 0000 2222                           36
  266 :8011 711 450   5  25  100                                                   50
  267 :8031  31 300   5  25  100                                                   50
  268 :8015 115 300   5  25  100                                                   50
  279 :  11  15  48 600         112  30                                           56
  280 :  15  11  48 600          92  50                                           56
  287 :   8                                                                      170
  438 : 3    16  12 200 1                                                        185
  439 : 2    15  16 400 2                                                        185
  447 :   9  30   0                                                              186
  448 :   1  30   0                                                              186
  449 :   7  30   0                                                              186
  450 :   18013 713  13  14  15  16  12 1217088 699   8   9 7088008             187
  451 :   38023  23  22  26  29 2917044 444   4   58006                         187
  452 :   1     1 2 3                                                            188
  453 :   3     7 8 9                                                            188
  454 :   1 300   0                                                              189
  455 :   3 300   0                                                              189
  664 :   1   0   0                                                              210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

Run Control Specifications

Link Geometry

Turning Movements

Signal Timing Plan

Entry Volumes

Parking Activity

Bus Transit

Implications of Punch Cards for Input

- **All inputs are alphanumeric (but almost exclusively numbers)**
- **Inputs require many codes and mental gymnastics**
  - Signal timing plans, bus routes, lane usage
- **Many opportunities for errors**
  - Inputs must be in proper column(s) on specific “card type”
  - Link data on multiple card types requires duplication of identifying info
  - No Windows dialog boxes or drop-down menus to prevent errors
  - No inputs could be trusted by software (**Each could be invalid!!**)
- **Don’t waste columns by using decimal points!**
  - Headway of 2.2 seconds input as 22 tenths of a second
- **Don’t DROP THE DECK!!**

Implications of Punch Cards for Software & Modeling

In a world where *every* input could be invalid:

- Such as non-integer where integer required, cards out of sequence or missing

- **Question everything! – Healthy sense of paranoia**
- **Consider what could go wrong**
- **Protect for errors**
- **Identify and question your assumptions**
- **Minimize, test assumptions**
- **Know what you expect to find in advance (back of the envelope thinking)**
- **Be patient and persistent!**
- **50% of NETSIM code was diagnostic!**

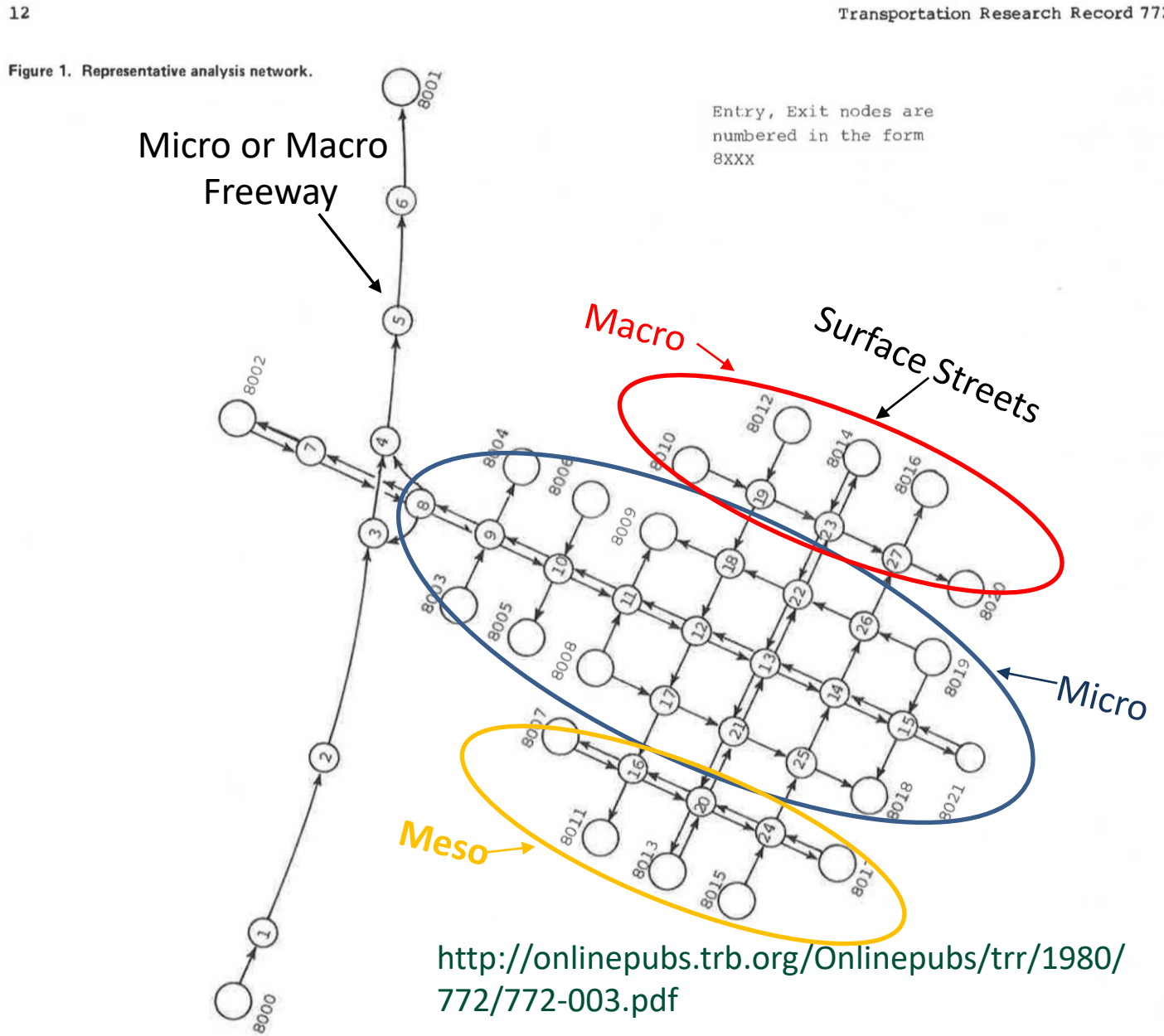
Everything old is new again!

- **Latest Thinking**
  - Hybrid modeling (micro, meso, macro)

- **1970s Thinking**
  - Hybrid modeling (micro, meso, macro)
  - FHWA's TRAF Family of Integrated Traffic Simulation models
  - Each model specialized for a ***single type of facility*** and level of detail

TRAF Concepts

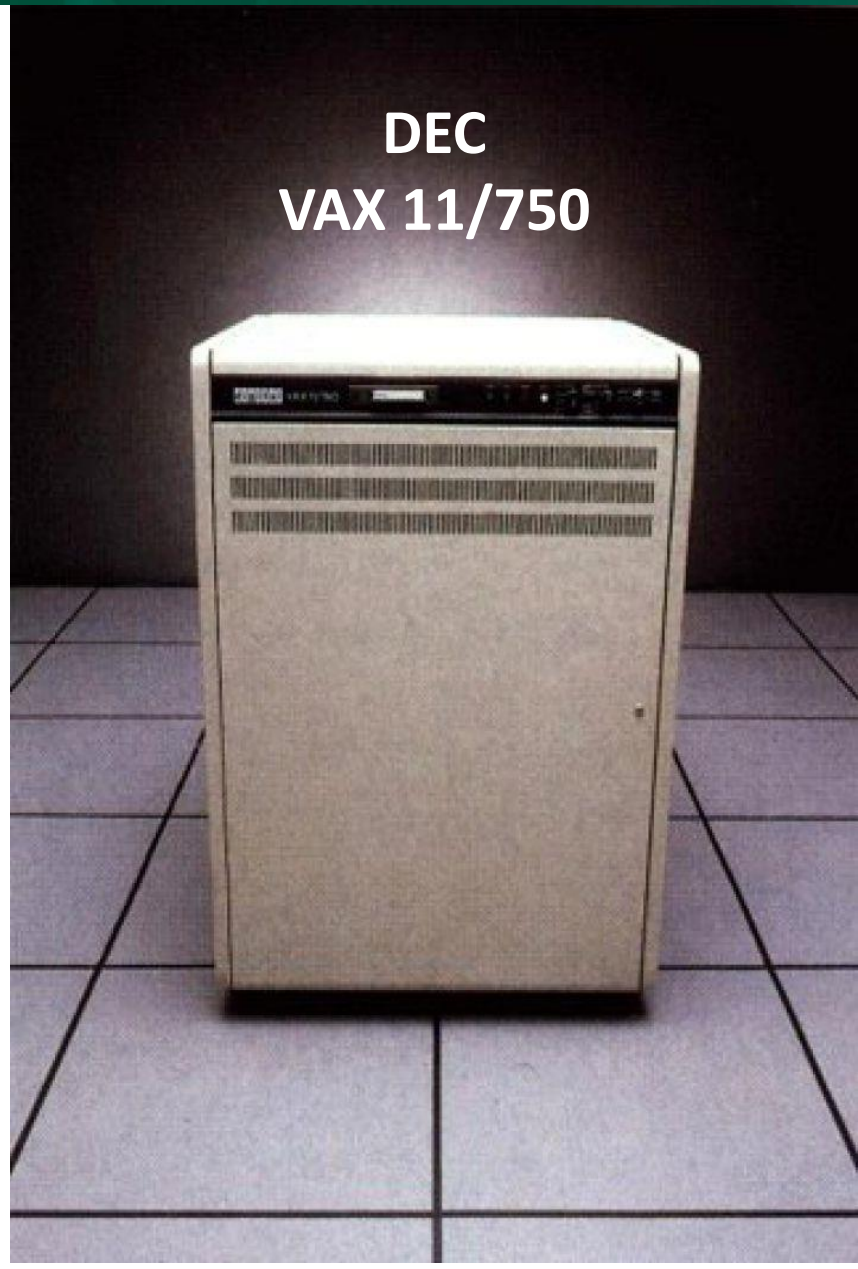
- **Network is divided into subnetworks**
- **Each subnetwork assigned to a TRAF program that suits its facility type and desired level of modeling detail**
- **Only 1 program & subnetwork in RAM at any time**
- **Addresses memory and cost issues of the era!!**



http://onlinepubs.trb.org/Onlinepubs/trr/1980/772/772-003.pdf

Computing in the 1980s

- **Minicomputers (computer disguised as a washing machine)**
  - $75K for VAX 11/750 minicomputer in 1984, ($193K today)
  - **1** MB of RAM and **121** MB hard drive (10 users!)
  - $10K for 2nd MB of RAM ($27.5K today)
  - Needed own room and air-conditioning with alarm
  - Terminals, keyboards and text editor
  - No more punch cards!
- **Laser Jet Printer at BNL cost $750K in 1981 ($2.2 million today)**



Computing in the 1980s

- **PCs able to run NETSIM ~ 1985**
- **3.5 hours to re-link code if anything changed**
- **New graphics cards and standards for drawing functions**
- **GTRAF software for static and animation displays in 1987**
- **Wider use of traffic simulation towards end of the decade into the 1990s**

IBM PC (1981)
Photo by Mark Richards
from The IBM PC

Modeling Advice from the 1970s and 1980s

- **Be patient!**
- **Give yourself the luxury of time to focus and think!**
- **Keep your eyes on the big picture – what must my model answer?**
- **Be more proactive and less reactive!**
  - Consider what can (and will) go wrong and protect for it
- **Know what you expect to find and confirm basics (back of the envelope thinking)**
  - (e.g., verify that correct number of cars discharge on a green signal)
- **Question EVERYTHING and keep a healthy sense of skepticism!**
- **Recognize and minimize your assumptions**
- **Test sensitivity of model results to the assumptions**

Discussion/Questions?

Thank you!

For more information contact:

Mark Yedlin

Director of Simulation Modeling Services

646.791.8802

myedlin@gpinet.com

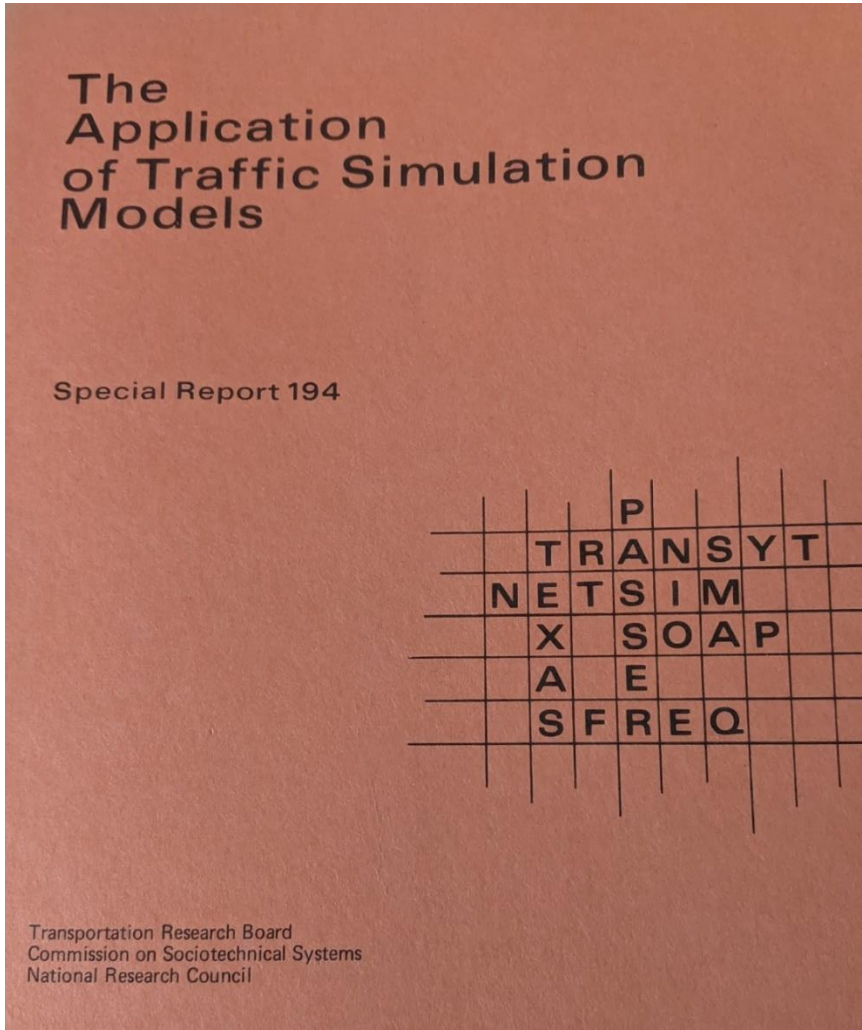
Greenman-Pedersen, Inc.

21 W. 38th Street, 6th Floor

New York, NY 10018

TRB Special Report 194

Proceedings from 1981 Conference on Traffic Simulation



Open Discussion

Thank You for Attending!

Christopher Melson
LTAP Program Manager
(225) 767-9118
cmelson1@lsu.edu

https://simcap.eng.lsu.edu/