FCSM/CDAC Disclosure Limiting Auditing Software: DAS

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Background

- To protect confidentiality, agencies suppress table cells that might reveal individual data.
- Software exists to select cells for suppression, provides no evaluation (http://www.eia.doe.gov/oss/disclosure.html).
- Auditing finds the lower and upper bounds on the values of a withheld (suppressed) cell.
- EIA lead an inter-agency project to prepare table auditing software, produced FCSM DAS.

Common Problem Seeking A Common Solution

- Seven Agencies Funded Software ($250k)
  - Bureau of Labor Statistics
  - Bureau of Economic Analysis
  - Bureau of the Census
  - National Center for Education Statistics
  - Internal Revenue Service
  - National Science Foundation
  - Energy Information Administration

Planned Uses of DAS

- Bureau of Labor Statistics (BLS)
  - DAS was tested and approved for use on Windows NT
  - Future BLS Statistical Order will require the use of DAS with the following:
    - ES-202 – Covered Employment and Wages
    - OSHS - Occupational Safety and Health Statistics
    - CES - Current Employment Statistics
    - OES - Occupational Employment Statistics

Planned Uses Continued…

- Energy Information Administration
  - Joint project with US Bureau of the Census working on developing auditing tools for processing of the 2002 Manufacturing Energy Consumption Survey
- National Science Foundation
  - Initial contact with NSF's contractor on executing DAS software

SWP Paper 22: Report on Statistical Disclosure Limitation Methodology

- Auditing Software (mid 1970's)
  - U.S. Census Bureau (Cox, 1980)
  - Statistics Canada (Sande, 1984)
- Audit systems produce upper and lower estimates for the suppressed cell based on linear combinations of published cells
- If software is already available, why DAS?

Software Requirements

- must be written in SAS© code, using macros language;
- must use the **PROC LP** (SAS/OR Software) as the linear optimizer;
- must be able to specify (as a LP model) and efficiently audit tables of up to 5 dimensions;

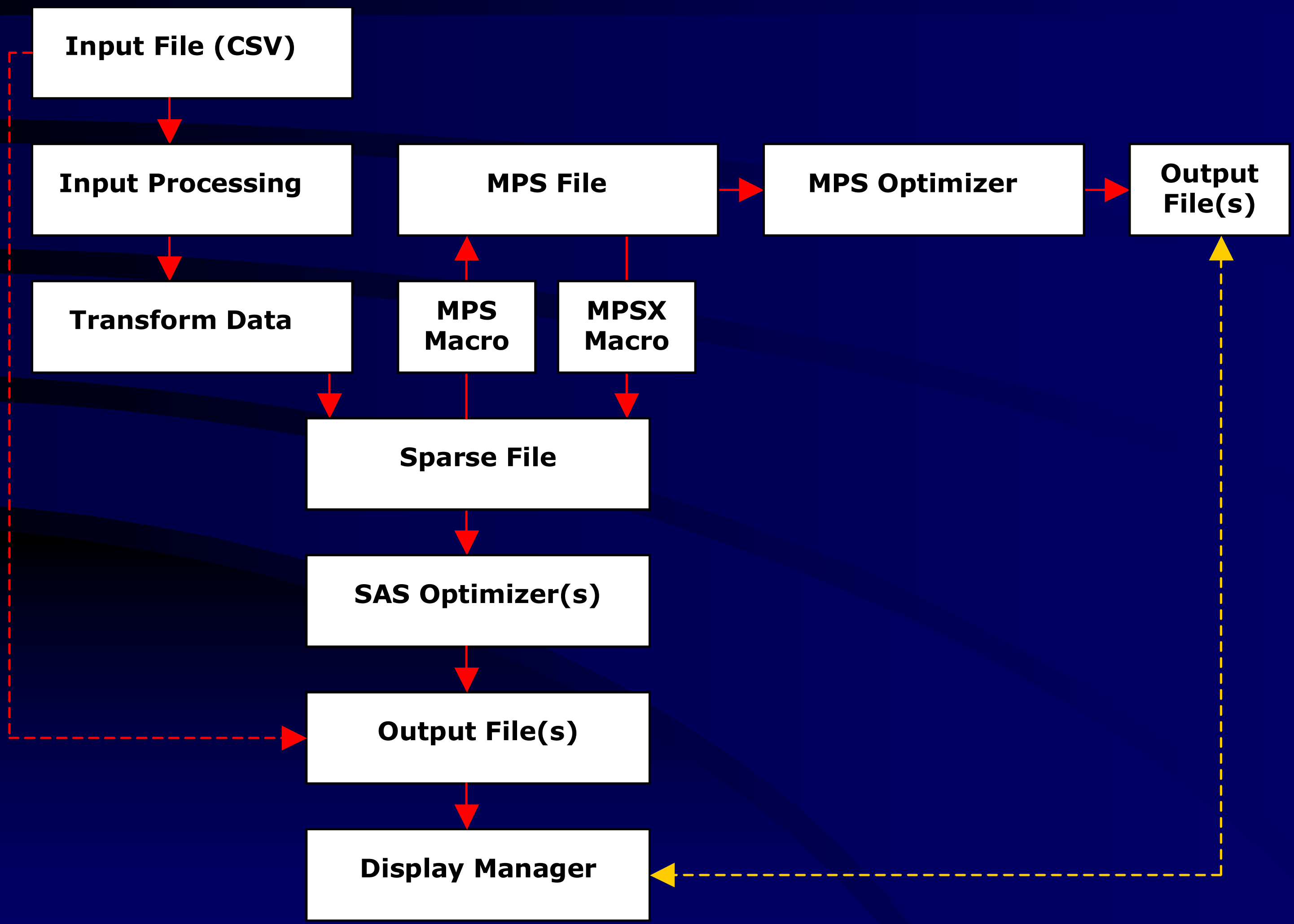
Requirements Continued...

- must display model results (e.g., minimum, maximum, protection range, and appropriate quality warnings) for all suppressed values;
- must use ASCII format for model statement input files; and,
- must pre-verify internal consistency of audit tables.

Modules of Software

- Front-End User Interface
- Pre-Verification of Audit Table(s)
  - Ensure Feasible Linear Model
    - Published Cell Values Sum to Published Totals
  - Rounding of Continuous Cell Values
  - Negative Cell Values
- Linear Program Modeling
- Results Display

Auditing Schematic



Pre-Verification

- Verify Aggregates
  - Dimension Totals and Marginal Totals
- Assume Maximum from Rounding Process
  - $e = \text{Max}\ \{e_i\}\ \forall\ i$
  - e is dictated by the rounding process; if rounded to integer e = 0.5
  - e is a variable defined by the user
- Pre-Verification Satisfies Inequality
  - $X_i - ne \leq X_. \pm e \leq X_i + ne$

2-D Example: Unrounded Table

				Total
	0.6	0.6	2.2	**3.4**
	1.0	1.0	0.6	**2.6**
	1.0	1.0	1.0	**3.0**
Total	**2.6**	**2.6**	**3.8**	**9.0**

2-D Example: Unrounded and Suppressed Table

				Total
	0.6	0.6	2.2	**3.4**
	1.0	V1	V2	**2.6**
	1.0	V3	V4	**3.0**
Total	**2.6**	**2.6**	**3.8**	**9.0**

Operations Research

- Linear Programming (LP) Model
  - Objective Min or Max v; *Subject to:*
    - $1.0 + v1 + v2 = 2.6$ (1)
    - $1.0 + v3 + v4 = 3.0$ (2)
    - $0.6 + v1 + v3 = 2.6$ (3)
    - $2.2 + v2 + v4 = 3.8$ (4)
    - $0.6 + 0.6 + 2.2 + 1.0 + 1.0 + v1 + v2 + v3 + v4 = 9.0$ (5)
    - $v \geq 0$
  - Feasible LP Model

LP Model Solutions

	Maximum	Minimum
V1	1.6	0.0
V2	1.6	0.0
V3	2.0	0.4
V4	1.6	0.0

2-D Example: Suppressed and Rounded

				Total
	1	1	2	**3**
	1	V1	V2	**3**
	1	V3	V4	**3**
Total	**3**	**3**	**4**	**9**

Operations Research

- Linear Programming (LP) Model 1
  - Objective **Min** or **Max** *v; Subject to:*
    - $1 + v1 + v2 = 3$ (1)
    - $1 + v3 + v4 = 3$ (2)
    - $1 + v1 + v3 = 3$ (3)
    - $2 + v2 + v4 = 4$ (4)
    - $1 + 1 + 2 + 1 + 1 + v1 + v2 + v3 + v4 = 9$ (5)
    - $v \geq 0$
  - Infeasible LP Model 1 due to Independent Rounding!

Infeasibility via Rounding

- Adding LP Constraints (1) and (2)
  - $v1 + v2 + v3 + v4 = 4$
- Adding LP Constraints (3) and (4)
  - $v1 + v2 + v3 + v4 = 4$
- However, reducing Constraint (5) yields
  - $v1 + v2 + v3 + v4 = 3$
- Hence, the LP model is <u>not</u> feasible.
- What to do?

How To Ensure Feasibility?

- Accounting for Independent Rounding
  - Add Surplus and Slack Variables to LP Equality Constraints - Not Used
  - Directly Adjust Table(s) - Not Used
  - Represent Rounding Found in Each Published Cell – Option in Current Use
  - "Best Fit" table approach (Stephen F. Roehrig, Carnegie Mellon University) – Future ?

From Tables to Constraints

- For each non-zero, unsuppressed cell value (u), create a new variable x and add the following constraint for each non-zero, unsuppressed cell.

$$u - e \leq x \leq u + e$$

- For withheld cells, associate a variable x, constrained only by non-negativity.

New LP Model Format

				Total
	X1	X2	X3	**X10**
	X4	X5	X6	**X11**
	X7	X8	X9	**X12**
Total	**X13**	**X14**	**X15**	**X16**

Revised LP Model

- Linear Programming (LP) Model 2
  - Objective Min or Max *x; Subject to:*
    - x1 + x2 + x3 = x10 (row 1)
    - x4 + x5 + x6 = x11 (row 2)
    - x7 + x8 + x9 = x12 (row 3)
    - ...and so forth
    - $u - e \leq X \leq u + e$ *or X* is non-negative
  - where *u* denotes non-zero, unsuppressed cell values and *e* is the max (+) rounding value

Revised Model Solutions

Bounds Expand

	Maximum	Minimum
V1	2.985648844	2.58562E-05
V2	2.985648844	2.58562E-05
V3	2.985648844	2.58562E-05
V4	2.985648844	2.58562E-05

Is there a another way?

- Assuming all *e's* take the maximum value has some ill effects
  - With large tables (i.e., large n) likely to obtain wide inequality bounds in verification and optimal solution sets (Kirkendall, Lu, Schipper, Roehrig 2001)
- Is there a better ways to assign values to e_i?
  - Heuristically assign a value to *e*
  - *Best-Fit* Approach

One Approach – Best-Fit Continuous Table (Roehrig)

- Directly adjust table cells in the LP model
  - Goal: Produce an additive table that generates the published table, given independent rounding
- "Best-Fit" table exists where objective function is the sum of absolute deviations
  - Minimize $Z = \quad | a_{ij} - x_{ij} |$ where i,j range over table rows and columns, a_{ij} are the published values, and x_{ij} are the LP variables

Software Status

- Distributed Beta Version in August 2000 to agencies on CDAC Sub-Committee
- Demonstration at EIA – March 2, 2001
  - Test files (csv format) provided by BEA and EIA
- Potential Additions
  - Add a user-friendly display manager system
  - Add a make-tables-add function (e.g., "Best Fit")
  - Add a non-SAS optimizer for optimization speed – CPLEX (www.cplex.com)
- Completed inter-agency agreements in August 2001 and distributed copies to those agencies.

System Requirements

- Operating Systems
  - Windows 95, 98, NT, and 2000
  - UNIX
- Operating Platforms
  - Stand-Alone PC
  - Windows "box"
  - UNIX "box"