**2018 END-TO-END TEST  
DISCLOSURE AVOIDANCE SYSTEM  
DESIGN SPECIFICATION**

**Version 1.3**

**July 9, 2019**

**This is version 1.3 of the Detailed Design Specification Guidance. Printed copies of this document may not contain the most recent updates**

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# 1 BACKGROUND

In 2020 the United States Census Bureau will conduct the 2020 Census which aims to enumerate every person residing in the United States, covering all 50 states, the District of Columbia and Puerto Rico. All persons alive on April 1, 2020 who reside in these places, according to residency criteria finalized in 2018, must be counted, including citizens, non-citizens, people of all ages, and races and ethnic groups.

The Census Bureau must submit state population totals to the United States President by December 31, 2020. The United States Constitution mandates this decennial enumeration, used to determine each state’s Congressional representation. Data from the Decennial Census is also used to aid in distributing funds from the federal to local level, and by the states for redistricting legislative districts.

As part of the Census Bureau’s collection activities, the Census Bureau by statue must assure that the Decennial Census data products meet the legal requirements of Title 13, Section 9 (a)(2) of the U.S. Code, which means the published results of the census must not identify individuals, nor should individuals be reasonably inferred.

In previous Decennial Censuses a variety of techniques were used to protect the confidentiality of responses, including the use of synthetic data and household swapping.[[1]](#footnote-1) For the 2020 Decennial the Census Bureau applied the latest science in developing the 2020 Disclosure Avoidance System (DAS). Following the instructions of the Data Stewardship Executive Policy Committee (DSEP), the Bureau implemented differential privacy (DP) as the primary methodology.

# 2 OVERVIEW

Article 1 Section 2 of the U.S. Constitution directs the U.S. Government to conduct an “actual enumeration” of the population every ten years.

The Census Bureau will conduct the next Census of Population and Housing with reference date April 1, 2020 and produce public-use data products that conform to the requirements of Title 13 of the U.S. Code. The goal is to count everyone once, only once, and in the right place.[[2]](#footnote-2) Per the code, all residents must be counted, including citizens, non-citizens, people of all ages, races and ethnic groups. After the data have been collected by the Census Bureau, but before the data are tabulated to produce data products for dissemination, the private data will undergo ***statistical disclosure limitation*** so that the impact of statistical data releases on respondent privacy can be quantified and controlled.

In the 2010 Census of Population and Housing, the trade-off between accuracy and privacy protection was viewed as a technical matter to be determined by disclosure avoidance statisticians. [[3]](#footnote-3) Disclosure avoidance was performed primarily using household-level record swapping and was supported by maintaining the secrecy of key disclosure avoidance parameters.

However, there is a growing recognition in the scientific community that record-level household swapping fails to provide provable privacy guarantees. There is also growing concern that it may be possible to reconstruct a significant portion of the confidential data that underlies the census data releases using a so-called ***database reconstruction attack***, as outlined by Dinur and Nissim (2003), and that such reconstructed microdata could be used to successfully re-identify the respondents who provided a significant proportion of the underlying confidential data.

In order to fulfill its requirements to produce an accurate count and to protect personally identifiable information, the Disclosure Avoidance System for the 2020 Census will implement a new approach to disclosure avoidance that applies mathematically rigorous disclosure avoidance controls to provide the required Title 13 data protections for the released data. The Disclosure Avoidance System (DAS) will read the Census Edited File (CEF) and apply formally private algorithms to produce a Microdata Detail File (MDF). By design, the CEF will contain information that is protected by Title 13, while the MDF will not.

Thus, the DAS can be thought of as a privacy filter or barrier, that allows some aspects of data to pass while preventing leaks of Title 13 data. As an important side effect, all data that are publicly released by the Census Bureau based on the 2020 Census must go through the 2020 Disclosure Avoidance System or an alternative mathematically defensible formally private disclosure avoidance system. This includes the PL94-171 redistricting data, any summary files, quality assurance reports shared outside the Census Bureau, and other kinds of statistical summaries.

# 3 DAS OPERATIONAL OVERVIEW

In production, the 2020 DAS operations team launches a pre-defined Amazon Web Services (AWS) Elastic Map Reduce (EMR) cluster. This cluster includes a bootstrap script that installs pre-defined DAS code and associated software on each of the member nodes.

AWS EMR supports three kinds of nodes: a single MASTER node, CORE nodes that are used for both data storage and for computation, and TASK nodes that are only used for computation. DAS will use a single MASTER node, at least two CORE nodes, and an indeterminate number of TASK nodes.

The data transferred (file at rest) to the storage bucket attached to these nodes are encrypted using the AWS Key Management Service (KMS) utilizing 256-bit Advanced Encryption Standard (AES) encryption. Once the file is transferred to the specified S3 bucket, the master node of the cluster reads and executes the DAS code. The DAS creates an internal representation of the estimated 341 million persons and 140 million households in the U.S. in 2020. This population is arranged in a multi-dimensional national histogram (MDNH). Measurements are taken at each geographical level. Statistical noise is added to the MDNH and to the per-level measurements, privatizing the assemblage of data. Finally, the results are post-processed to create a consistent set of microdata that can be used for tabulation.

# 4 DAS INFRASTRUCTURE SPECIFICATION

##### aws cluster instantiation and bootstrap configuration

The DAS cluster infrastructure is a managed service provided by the Technical Integration (TI) program. The TI controls the cluster configuration which includes the AWS machine type, number of nodes for each cluster, node types for both head and core nodes, and the amount and configuration of allocated AWS Elastic Block Store (EBS) attached to each cluster node. A typical DAS baseline cluster configuration consists of the following AWS EMR cluster node specifications.

Table 1: Typical Cluster Specification - Technical Infrastructure 2020 AWS Cloud Environment

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AWS Cluster Node Type** | **AWS EMR Cluster Role** | **Node Count** | **vCPU (Cores)** | **RAM**  **(GB)** | **EBS Storage (GB)** |
| **MASTER** | m4.16xlarge | 1 | 6 | 256 GB | 1000 GB |
| **CORE** | r4.16xlarge | 10 | 488 GB | 4000 GB |
| **TASK** | 20 | 1000 GB |

After the TI instantiates the cluster, a sequence of bootstrap scripts installs and configures the software necessary for DAS to execute. The first bootstrap script installs the AWS Amazon Linux (Center for Internet Security (CIS) Secure Baseline) hardened image, and installs the necessary end protection, security and monitoring tools.

After the first bootstrap script completes, a second bootstrap script installs the necessary DAS components and software tools. This bootstrap also configures the necessary cluster permissions, license configurations for the Gurobi Optimizer and other DAS-specific node configuration settings. This completes the cluster instantiation step.

The completion of the bootstrap on every node causes the DAS Step 1 script to execute on the master node which executes the DAS Core Application Framework.

##### acquiring and verifying the cef

When the DAS starts the CEF has been pre-positioned in an appropriate S3 bucket at a pre-specified location. The DAS verifies that the CEF is present and properly formatted.

##### das core application

DAS next executes the Top-Down DAS algorithm using the approach outlined below. This algorithm utilizes the Gurobi optimizer in parallel to generate microdata maximally consistent with a set of noisy (formally private) measurements.

First, at the national level, between 500,000 and 3,000,000 differentially private, noisy summary query measurements are taken, on which some pre-specified proportion of the global privacy budget is expended (e.g. 1/6 of total privacy budget might be spent, if the global budget is evenly split between the geographic levels).

* These summary queries are then post-processed (primarily through the solution of large-scale linear programming, quadratic programming, and mixed-integer linear/quadratic programming models constructed and solved with the Gurobi Optimizer) to generate a national-level histogram that is informationally equivalent to microdata because it is identical to the fully-saturated contingency table representation. This creates a set of non-negative, integer counts of persons and households consistent with invariants (counts to be released exactly as enumerated) agreed to by the Census Bureau’s Data Stewardship Executive Policy Committee (DSEP).
* The synthetic individual and household records generated at the national level are then allocated to the 51 state-equivalent geographies using a second formally private algorithm, which again involves taking differentially private measurements (this time returning noisy counts at the state level) and generating histograms (i.e., microdata) of persons and households (but now at the state level) consistent with known invariants.[[4]](#footnote-4)
* In analogous fashion, the individuals and households in each state are then allocated to counties, and then to census tracts, and then to block groups, and finally to blocks (some intermediate geographic levels may also be introduced intermediately for purely technical reasons).
* The taking of formally private measurements at each geographic level in order to make informed microdata-generation and allocation decisions consumes some portion of the privacy-loss budget.
* With each allocation, the DAS assures that several variables will be “invariant” — that is, that the tabulations of the synthetic data exactly match the tabulations of the CEF. For the 2010 Census and the 2018 End-to-End test, the invariants are listed in Table 2:
  + - **C1:** Total population (invariant at the county level for the 2018 E2E)
    - **C2:** Number of housing units (invariant at the block level)
    - **C3:** Number of occupied housing units (invariant at the block level)
    - **C4:** Number of group quarters facilities by group quarters type (invariant at the block level)
* For other variables, the DAS will attempt to make the allocation of synthetic individuals match as closely as possible the actual tabulations of these variables in the CEF within the constraints allowed by the privacy-loss budgets. This goal is achieved by expending the privacy budget as wisely as is possible when taking formally private measurements at each geographic level, and then using mathematical optimization to generate microdata/allocations that closely match the noisy measurements taken.

Table 2: 2010 Census and 2018 End-to-End Test Invariants

|  |  |  |  |
| --- | --- | --- | --- |
| **Invariant** | **Definition** | **2010 Geographic Level** | **2018 End-to-End Test Geographic Level** |
| **C1** | Total population | block | Providence, RI |
| **C2** | Voting-age population | block | removed |
| **C3** | Number of housing units | block | block |
| **C4** | Number of occupied housing units | block | block (note a) |
| **C5** | Number and type of group quarters | block | block (note b) |
| ***Notes:*** (a) DSEP recommended removing this invariant but the code base could not be adjusted in time for the test processing; (b) seven types of group quarters are invariant in the redistricting data prototype. | | | |

##### end of processing

After DAS processing, the MDF file is then written back to the specified S3 bucket, again encrypted at rest using AWS KMS. The file is then transferred to other Decennial systems for further processing.

##### microdata file specifications

This section of the document outlines the Decennial Census Management Division (DCMD), Center for Enterprise Dissemination - Disclosure Avoidance (CED-DA), and Decennial Information Technology Division (DITD) the specifications to create the Microdata Detail File. This specification contains the Record Layouts for the two sections of the MDF.

Table 3: Production Input

|  |  |
| --- | --- |
| **Data Title** | **Data File Name** |
| Census Edited File (CEF) | CEF\_COUNTS.txt  CEF\_PER.txt  CEF\_UNIT.txt |
| Tab GRFC | grfc\_tab18\_44007.txt |

Table 4: Production Output

|  |  |
| --- | --- |
| **Data Title** | **Data File Name** |
| Microdata Detail File (MDF) | MDF\_PER.txt  MDF\_UNIT.txt |

Table 5: Glossary and Conventions used in Record Layouts

|  |  |
| --- | --- |
| **Terminology** | **Definition** |
| CENHISP | A recode of the eight edited Hispanic origin codes into 2 values representing Hispanic and not Hispanic. |
| CENRACE | A recode of the eight edited race codes into a single 2-digit code representing one of 63 race group categories. |
| CHAR(#) | A fixed-width field of # characters long. **CHAR is used for numbers if the numbers are not used for mathematical operations. CHAR is used for zero-filled numbers.** |
| **Disclosure Avoidance (DA)** | Items noted with Disclosure Avoidance (DA) have undergone disclosure avoidance in accordance with DSEP policy. |
| FINAL\_POP | Final Population Count from the CUF – includes count imputation. |
| Linkage Variable | A variable that links between two tables. |
| INT(#) | An Integer up to # characters wide. Not zero-filled. |
| **Not Reported** | Items noted as Not Reported in the 2018 MDF represent data that might be included in the 2020 MDF but are not present in the 2018 MDF due to policy or procedural reasons. They are indicated with the notation “Not Reported” |
| Pipe delimited | A “pipe-delimited” file is a text file in Unicode UTF-8 encoding in which each field is separated by the Unicode Character “VERTICAL LINE” (U+007C) (e.g. “|”) also known as the “pipe” character from its use in Unix pipelines. |
| QAGE | Edited Age as defined in the Edits and Characteristics Imputation Specification. |
| QRACEX | Edited Race Groups as defined in the Edits and Characteristics Imputation Specification. |
| QREL | Edited Relationships as defined in the Edits and Characteristics Imputation Specification. |
| QSEX | Edited Sex as defined in the Edits and Characteristics Imputation Specification. |
| Recode | A recode is a new variable that is created by combining or collapsing the value categories of an existing variable |
| Protected recode | A protected recode is a new variable created from **existing** **protected** variables. |
| Redundant; Remove | Items noted as Redundant exactly replicate other items already in the MDF. |
| RTYPE | Record Type |
| TEN | Edited Tenure |

##### micro data file record layouts

Microdata Detail File (MDF) Person Data.

Data will be pipe-delimited.

This table links to MDF.Unit using the EUID linkage variable.

This table links to GRF-C using the TABBLKST, TABBLKCOU, TABTRACTCE, TABBLKGRPCE, and TABBLK linkage variables.

Table 6: MDF.Person

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***#*** | ***Name*** | ***Label*** | ***Type*** | ***Values*** |
| 1 | **SCHEMA\_TYPE\_CODE** | Schema Type Code | CHAR(5) | MPD |
| 2 | **SCHEMA\_BUILD\_ID** | Schema Build ID | CHAR(5) | 3.1.4 |
| 3 | **TABBLKST** | 2018 Tabulation State (FIPS) | CHAR(2) | 01-02  04-06  08-13  15-42  44-51  53-56  72 |
| 4 | **TABBLKCOU** | 2018 Tabulation County (FIPS) | CHAR(3) | 001-840  **Note:** Char(4): 0001-8400 in 2018 End-to-End |
| 5 | **TABTRACTCE** | 2018 Tabulation Census Tract | CHAR(6) | 000100-998999  **Note:** Not reported in 2018 End-to-End |
| 6 | **TABBLKGRPCE** | 2018 Census Block Group | CHAR(1) | 0-9  **Note:** Not reported in 2018 End-to-End |
| 7 | **TABBLK** | 2018 Block Number | CHAR(4) | 0001-9999  **Note:** Not reported in 2018 End-to-End |
| 8 | **ENUMDIST** (Note: 1940 variable only) | Enumeration District | Char(4) | 0000-9999  **Note:** Only reported in 2018 End-to-End |
| 9 | **EUID** | Privacy Edited Unit ID | INT(9) | 0-999999999 |
| 10 | **EPNUM** | Privacy Edited Person Number | INT(5) | 0-99999  **Note:** For households, EPNUM = 1 assigned to the householder (QREL = 01) |
| 11 | **RTYPE** | Record Type | CHAR(1) | 3 = Person in housing unit |
| 5 = Person in group quarters |
| 12 | **QREL** | Edited Relationship | CHAR(2) | 01 = Householder  02 = Opposite-sex husband/wife/spouse  03 = Opposite-sex unmarried partner  04 = Same-sex husband/wife/spouse  05 = Same-sex unmarried partner  06 = Biological son/daughter  07 = Adopted son/daughter  08 = Stepson/stepdaughter  09 = Brother/sister  10 = Father/mother  11 = Grandchild  12 = Parent-in-law  13 = Son-in-law/daughter-in-law  14 = Other relative  15 = Housemate/roommate  16 = Foster child  17 = Other nonrelative  18 = Institutional Group Quarters Person  19 = Non-institutional Group Quarters Person  99 = Not reported in 2018 End-to-End |
| 13 | **QSEX** | Edited Sex | CHAR(1) | 1 = Male  2 = Female  9 = Not reported in 2018 End-to-End |
| 14 | **QAGE** | Edited Age | INT(3) | 0-115  **Note:** For 2018 End-to-End:  QAGE = 17 assigned to minors, and  QAGE = 18 assigned to voting age persons |
| 15 | **CENHISP** | Hispanic Origin | CHAR(1) | 1 = Not Hispanic  2 = Hispanic |
| 16 | **CENRACE** | Census Race | CHAR(2) | 01 = White alone  02 = Black alone  03 = AIAN alone  04 = Asian alone  05 = NHPI alone  06 = SOR alone  07 = White; Black  078 = White; AIAN  09 = White; Asian  10 = White; NHPI  11 = White; SOR  12 = Black; AIAN  13 = Black; Asian  14 = Black; NHPI  15 = Black; SOR  16 = AIAN; Asian  17 = AIAN; NHPI  18 = AIAN; SOR  19 = Asian; NHPI  20 = Asian; SOR  21 = NHPI; SOR  22 = White; Black; AIAN  23 = White; Black; Asian  24 = White; Black; NHPI  25 = White; Black; SOR  26 = White; AIAN; Asian  27 = White; AIAN; NHPI  28 = White; AIAN; SOR  29 = White; Asian; NHPI  30 = White; Asian; SOR  31 = White; NHPI; SOR  32 = Black; AIAN; Asian  33 = Black; AIAN; NHPI  34 = Black; AIAN; SOR  35 = Black; Asian; NHPI  36 = Black; Asian; SOR  37 = Black; NHPI; SOR  38 = AIAN; Asian; NHPI  39 = AIAN; Asian; SOR  40 = AIAN; NHPI; SOR  41 = Asian; NHPI; SOR  42 = White; Black; AIAN; Asian  43 = White; Black; AIAN; NHPI  44 = White; Black; AIAN; SOR  45 = White; Black; Asian; NHPI  46 = White; Black; Asian; SOR  47 = White; Black; NHPI; SOR  48 = White; AIAN; Asian; NHPI  49 = White; AIAN; Asian; SOR  50 = White; AIAN; NHPI; SOR  51 = White; Asian; NHPI; SOR  52 = Black; AIAN; Asian; NHPI  53 = Black; AIAN; Asian; SOR  54 = Black; AIAN; NHPI; SOR  55 = Black; Asian; NHPI; SOR  56 = AIAN; Asian; NHPI; SOR  57 = White; Black; AIAN; Asian; NHPI  58 = White; Black; AIAN; Asian; SOR  59 = White; Black; AIAN; NHPI; SOR  60 = White; Black; Asian; NHPI; SOR  61 = White; AIAN; Asian; NHPI; SOR  62 = Black; AIAN; Asian; NHPI; SOR  63 = White; Black; AIAN; Asian; NHPI; SOR  **Note:** Only values 0 through 6 reported in 2018 End-to-End |
| 17 | **QSPANX** | Edited Hispanic Origin Group | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 18 | **QRACE1** | Edited Detailed Race 1 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 19 | **QRACE2** | Edited Detailed Race 2 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 20 | **QRACE3** | Edited Detailed Race 3 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 21 | **QRACE4** | Edited Detailed Race 4 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 22 | **QRACE5** | Edited Detailed Race 5 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 23 | **QRACE6** | Edited Detailed Race 6 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 24 | **QRACE7** | Edited Detailed Race 7 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 25 | **QRACE8** | Edited Detailed Race 8 | CHAR(4) | 9999 = Not reported in 2018 End-to-End |
| 26 | **CIT** | Citizenship | CHAR(1) | 9 = Not reported in 2018 End-to-End |

Microdata Detail File (MDF) Unit Data.

Data will be pipe-delimited.

This table links to MDF.Person using the EUID linkage variable.

This table links to GRF-C using the TABBLKST, TABBLKCOU, TABTRACTCE, TABBLKGRPCE, and TABBLK linkage variables.

Table 7: MDF.Unit

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***#*** | ***Name*** | ***Label*** | ***Type*** | ***Values*** |
| 1 | **SCHEMA\_TYPE\_CODE** | Schema Type Code | CHAR(5) | MUD |
| 2 | **SCHEMA\_BUILD\_ID** | Schema Build ID | CHAR(5) | 3.1.4 |
| 3 | **TABBLKST** | 2018 Tabulation State (FIPS) | CHAR(2) | 01-02  04-06  08-13  15-42  44-51  53-56  72 |
| 4 | **TABBLKCOU** | 2018 Tabulation County (FIPS) | CHAR(3) | 001-840  **Note:** Char(4): 0001-8400 in 2018 End-to-End |
| 5 | **TABTRACTCE** | 2018 Tabulation Census Tract | CHAR(6) | 000100-998999  **Note:** Not reported in 2018 End-to-End |
| 6 | **TABBLKGRPCE** | 2018 Census Block Group | CHAR(1) | 0-9  **Note:** Not reported in 2018 End-to-End |
| 7 | **TABBLK** | 2018 Block Number | CHAR(4) | 0001-9999  **Note:** Not reported in 2018 End-to-End |
| 8 | **ENUMDIST** (Note: 1940 variable only) | Enumeration District | Char(4) | 0000-9999  **Note:** Only reported in 2018 End-to-End |
| 9 | **EUID** | Privacy Edited Unit ID | INT(9) | 0-999999999 |
| 10 | **RTYPE** | Record Type | CHAR(1) | 2 = Housing unit  4 = Group quarters |
| 11 | **GQTYPE** | Group Quarters Type | CHAR(3) | 000 = NIU  101 = Federal detention centers  102 = Federal prisons  103 = State prisons  104 = Local jails and other municipal confinement facilities  105 = Correctional residential facilities  106 = Military disciplinary barracks and jails  201 = Group homes for juveniles (non-correctional)  202 = Residential treatment centers for juveniles (non-correctional)  203 = Correctional facilities intended for juveniles  301 = Nursing facilities/skilled nursing facilities  401 = Mental (psychiatric) hospitals and psychiatric units in other hospitals  402 = Hospitals with patients who have no usual home elsewhere  403 = In-patient hospice facilities  404 = Military treatment facilities with assigned patients  405 = Residential schools for people with disabilities  501 = College/university student housing (college/university owned/leased/managed)  502 = College/university housing (privately owned/leased/managed)  601 = Military quarters  602 = Military ships  701 = Emergency and transitional shelters (with sleeping facilities) for people experiencing homelessness  702 = Soup kitchens  704 = Regularly scheduled mobile food vans  706 = Targeted non-sheltered outdoor locations  801 = Group homes intended for adults  802 = Residential treatment centers for adults  900 = Maritime/merchant vessels  901 = Workers' group living quarters and job corps centers  903 = Living quarters for victims of natural disasters  904 = Religious group quarters and domestic violence shelters  **Note:** For 2018 End-to-End, only the first digit is reported. |
| 12 | **TEN** | Tenure | CHAR(1) | 0 = NIU  1 = Owned with a mortgage  2 = Owned free and clear  3 = Rented  4 = Occupied without payment of rent  9 = Occupied unit in 2018 End-to-End |
| 13 | **VACS** | Vacancy Status | CHAR(1) | 0 = NIU  1 = Vacant, for rent  2 = Vacant, rented, not occupied  3 = Vacant, for sale only  4 = Vacant, sold, not occupied  5 = Vacant, for seasonal, recreational, or occasional use  6 = Vacant, for migrant workers  7 = Vacant, other  9 = Vacant unit in 2018 End-to-End |
| 14 | **FINAL\_POP** | Population Count | INT(5) | 0-99999  **Note:** Int(2): 0-99 in 1940 data |
| 15 | **HHT** | Household/Family Type | CHAR(1) | 0 = NIU  1 = Married couple household  2 = Other family household: Male householder  3 = Other family household: Female householder  4 = Nonfamily household: Male householder, living alone  5 = Nonfamily household: Male householder, not living alone  6 = Nonfamily household: Female household, living alone  7 = Nonfamily household: Female household, not living alone  9 = Not reported in 2018 End-to-End |
| 16 | **HHT2** | Household/Family Type (NEW) | CHAR(2) | 00 = NIU  01 = Married couple household: With own children < 18  02 = Married couple household: No own children < 18  03 = Cohabiting couple household: With own children < 18  04 = Cohabiting couple household: No own children < 18  05 = Female householder, no spouse/partner present: Living alone  06 = Female householder, no spouse/partner present: With own children < 18  07 = Female householder, no spouse/partner present: With relatives, no own children < 18  08 = Female householder, no spouse/partner present: Only nonrelatives present  09 = Male householder, no spouse/partner present: Living alone  10 = Male householder, no spouse/partner present: With own children < 18  11 = Male householder, no spouse/partner present: With relatives, no own children < 18  12 = Male householder, no spouse/partner present: Only nonrelatives present  99 = Not reported in 2018 End-to-End |
| 17 | **NPF** | Number of People in Family | INT(2) | 0 = NIU  2-97  99 = Not reported in 2018 End-to-End |
| 18 | **CPLT** | Couple Type | CHAR(1) | 0 = NIU  1 = Opposite-sex husband/wife/spouse household  2 = Same-sex husband/wife/spouse household  3 = Opposite-sex unmarried partner household  4 = Same-sex unmarried partner household  9 = Not reported in 2018 End-to-End |
| 19 | **UPART** | Presence and Type of Unmarried Partner Household | CHAR(1) | 0 = NIU  1 = Male householder and male partner  2 = Male householder and female partner  3 = Female householder and female partner  4 = Female householder and male partner  5 = All other households  9 = Not reported in 2018 End-to-End |
| 20 | **MULTG** | Multigenerational Household | CHAR(1) | 0 = NIU  1 = Not a multigenerational household  2 = Yes, a multigenerational household  9 = Not reported in 2018 End-to-End |
| 21 | **HHLDRAGE** | Age of Householder | INT(3) | 0 = NIU  15-115  999 = Not reported in 2018 End-to-End |
| 22 | **HHSPAN** | Hispanic Householder | CHAR(1) | 0 = NIU  1 = Not Hispanic  2 = Hispanic  9 = Not reported in 2018 End-to-End |
| 23 | **HHRACE** | Race of Householder | CHAR(2) | 00 = NIU  01 = White alone  02 = Black alone  03 = AIAN alone  04 = Asian alone  05 = NHPI alone  06 = SOR alone  07 = White; Black  08 = White; AIAN  09 = White; Asian  10 = White; NHPI  11 = White; SOR  12 = Black; AIAN  13 = Black; Asian  14 = Black; NHPI  15 = Black; SOR  16 = AIAN; Asian  17 = AIAN; NHPI  18 = AIAN; SOR  19 = Asian; NHPI  20 = Asian; SOR  21 = NHPI; SOR  22 = White; Black; AIAN  23 = White; Black; Asian  24 = White; Black; NHPI  25 = White; Black; SOR  26 = White; AIAN; Asian  27 = White; AIAN; NHPI  28 = White; AIAN; SOR  29 = White; Asian; NHPI  30 = White; Asian; SOR  31 = White; NHPI; SOR  32 = Black; AIAN; Asian  33 = Black; AIAN; NHPI  34 = Black; AIAN; SOR  35 = Black; Asian; NHPI  36 = Black; Asian; SOR  37 = Black; NHPI; SOR  38 = AIAN; Asian; NHPI  39 = AIAN; Asian; SOR  40 = AIAN; NHPI; SOR  41 = Asian; NHPI; SOR  42 = White; Black; AIAN; Asian  43 = White; Black; AIAN; NHPI  44 = White; Black; AIAN; SOR  45 = White; Black; Asian; NHPI  46 = White; Black; Asian; SOR  47 = White; Black; NHPI; SOR  48 = White; AIAN; Asian; NHPI  49 = White; AIAN; Asian; SOR  50 = White; AIAN; NHPI; SOR  51 = White; Asian; NHPI; SOR  52 = Black; AIAN; Asian; NHPI  53 = Black; AIAN; Asian; SOR  54 = Black; AIAN; NHPI; SOR  55 = Black; Asian; NHPI; SOR  56 = AIAN; Asian; NHPI; SOR  57 = White; Black; AIAN; Asian; NHPI  58 = White; Black; AIAN; Asian; SOR  59 = White; Black; AIAN; NHPI; SOR  60 = White; Black; Asian; NHPI; SOR  61 = White; AIAN; Asian; NHPI; SOR  62 = Black; AIAN; Asian; NHPI; SOR  63 = White; Black; AIAN; Asian; NHPI; SOR  99 = Not reported in 2018 End-to-End |
| 24 | **PAOC** | Presence and Age of Own Children Under 18 | CHAR(1) | 0 = NIU  1 = With own children under 6 year only  2 = With own children 6-17 years only  3 = With own children under 6 years and 6-17 years  4 = No own children  9 = Not reported in 2018 End-to-End |
| 25 | **P18** | Number of People Under 18 Years in Household | INT(2) | 0 = NIU  1-97  99 = Not reported in 2018 End-to-End |
| 26 | **P60** | Number of People 60 Years and Over in Household | INT(2) | 0 = NIU  1-97  99 = Not reported in 2018 End-to-End |
| 27 | **P65** | Number of People 65 Years and Over in Household | INT(2) | 0 = NIU  1-97  99 = Not reported in 2018 End-to-End |
| 28 | **P75** | Number of People 75 Years and Over in Household | INT(2) | 0 = NIU  1-97  99 = Not reported in 2018 End-to-End |

# 5 DESIGN PLAN SPECIFICATIONS

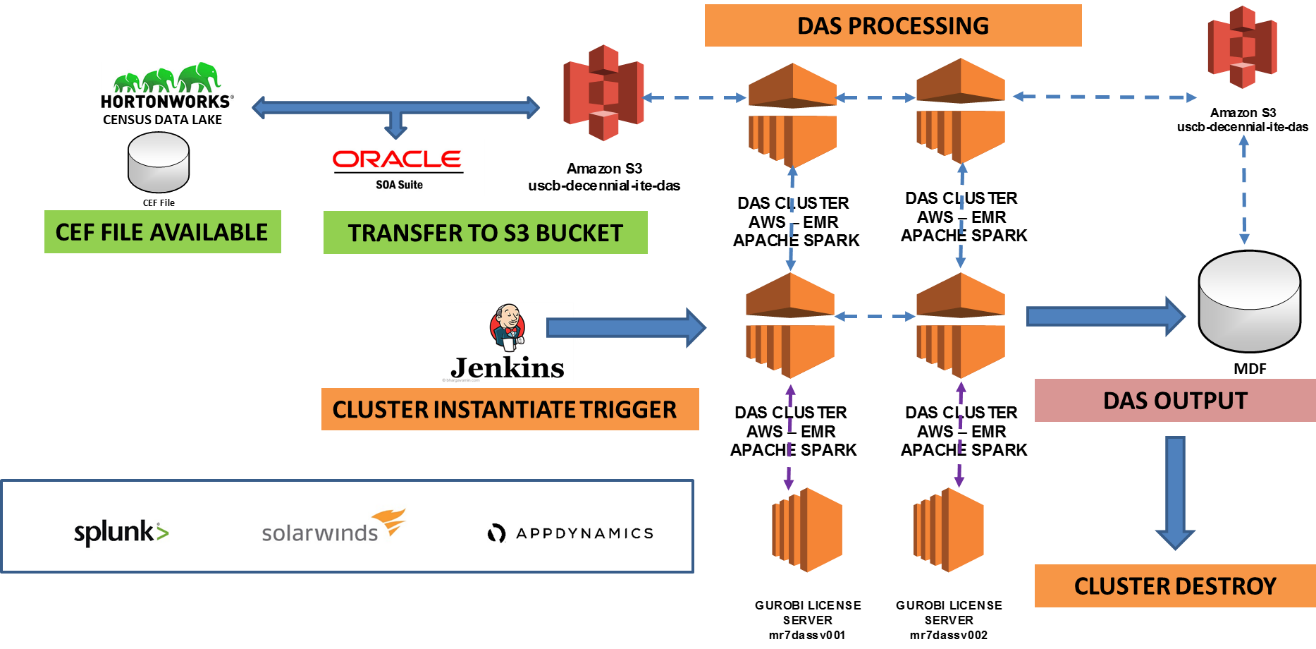
The DAS design plan can be described by the following components:

##### das cluster infrastructure

DAS utilizes AWS GovCloud and the following AWS components:

* AWS Elastic Map Reduce (EMR) Cluster installed with Apache Spark
* AWS Simple Storage Service (S3)
* AWS Simple Notification Service (SNS)
* AWS Elastic Block Store (EBS)
* AWS Elastic Compute Cloud (EC2)

Figure 1: DAS Cluster Infrastructure



##### das ⇔ s3 interface framework

DAS receives the Census Edited File (CEF) from S3 writes back the results as a Micro Data File (MDF).

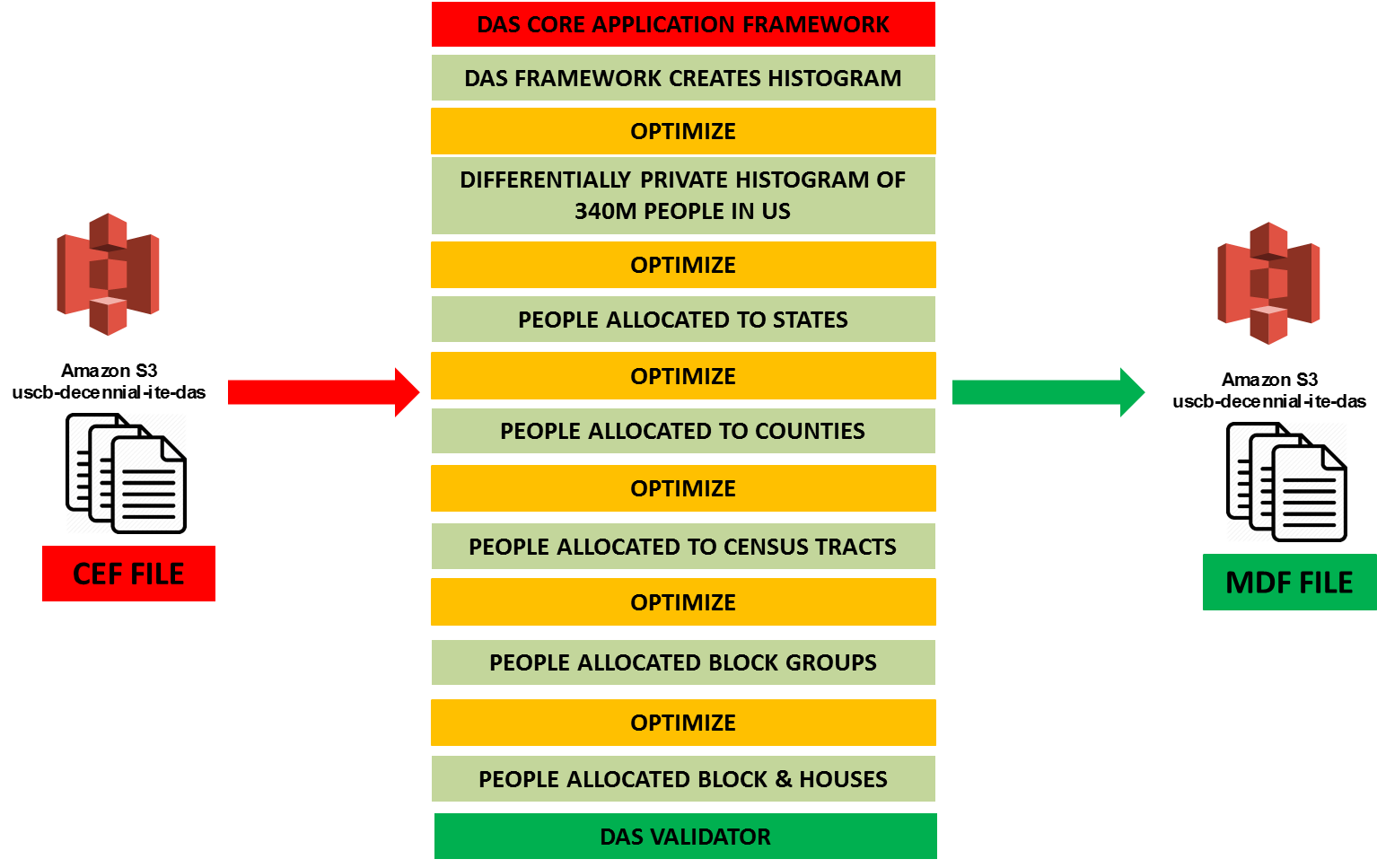
##### das core application framework

The Disclosure Avoidance System (DAS) applies privacy controls to microdata in the data flow from the Census Edited File (CEF) to the Microdata Detail File (MDF). The privacy controls assure that there is no direct mapping between individual records in the CEF to individual records in the MDF and regulate the privacy loss implied by the production of the MDF.

Following the application of the privacy controls, the microdata in the MDF is ready for tabulation. By design, the MDF does not need to be protected under Title 13, and could, for example, be publicly released.

The CEF contains other private information that is not destined for the MDF to support other Census business processes. Gurobi optimization software is used by DAS for mathematical optimization (typically to generate or allocate microdata from noisy measurements).

Figure 2: DAS Core Application Framework



# 6 SYSTEM ARCHITECTURE

The section below provides an overview of the DAS System Architecture.

##### business architecture

DAS is solving a particular data-processing problem for the Census Bureau, that is to apply disclosure avoidance and privacy controls to uphold Title 13 mandated confidentiality protections to the data published from the 2020 Census. DAS is not integrated into, nor solving any Census Bureau operational, business, financial, or transactional functions.

##### application architecture (front end)

DAS is designed and built without user access. DAS employs a single DAS operations account to run DAS from start to completion. No front-end user interface is built into DAS.

##### information architecture (data)

DAS is designed and architected without any user data input, data transactions or data storage requirements. DAS will not employ a database engine in order to complete the system’s intended use case.

##### data-at-rest security controls:

##### cluster node(s) attached elastic block storage (ebs)

When an ***encrypted*** Amazon EBS volume is attached to a supported Amazon Elastic Map Reduce (EMR) instance, data stored at rest on the volume, disk I/O, and snapshots created from the volume are all encrypted. Amazon EBS encryption uses AWS Key Management Service (AWS KMS) customer master keys (CMKs) when creating encrypted volumes and any snapshots created from them. The encryption occurs on the servers that host Amazon Elastic Map Reduce (EMR) cluster node members. When the DAS EMR cluster is instantiated an ***encrypted EBS volume*** is automatically attached to all the node members, as a result the following types of data are encrypted:

* Data at rest inside the volume
* All data moving between the volume and the instance
* All snapshots created from the volume
* All volumes created from those snapshots

##### s3 bucket data encryption

The TI 2020 Cloud supports AWS S3 bucket integration for AWS EMR. Every cluster that requires S3 storage will be assigned a specific S3 storage bucket, restricted to each project cluster node members and configured to encrypt any file stored to the assigned bucket. Amazon S3 encryption provides a way to set the encryption behavior for an S3 bucket. DAS AWS EMR sets encryption on a bucket so that all objects are encrypted when they are stored in the bucket. The objects are encrypted using server-side encryption AWS KMS-managed keys (SSE-KMS).

##### data-in-flight security controls:

Clusters instantiated within the TI 2020 Cloud, will be installed with TLS certificates for node-to-node communications for EMR-specific task execution.

##### baseline management

Architecture, infrastructure and code baseline management will adhere to the TI-2020 Program Change Management Plan.

# 7 CLOUD BASED SECURITY CONSIDERATIONS

Table 8: Cloud Based Security Considerations

|  |  |
| --- | --- |
| **Consideration** | **Response** |
| Uptime expectation from the Business Owner of the System in the Cloud: | 100% |
| Cloud Based SLA for security monitoring: | 100% |
| Cloud Based System Level High Availability: | YES |
| Cloud Based Site Level Disaster Recovery for the System: | Provided TI 2020 Cloud Capability |
| State whether the Cloud Vendor is FEDRAMP Certified: | YES |
| Data Retention Requirements: | YES |

# 8 RELIABILITY, MAINTAINABILITY AND AVAILABILITY CONSIDERATIONS

The design of the system is such that there is a single MASTER node and multiple WORKER and/or CORE nodes. If a WORKER/CORE node fails, the EMR system will restart that load and schedule work one the failed node to be re-computed on a new node. However, there are no provisions in EMR for a failed MASTER node. If the MASTER node fails, the system will need to be manually restarted.

The current design has minimal built in checks. If the system fails during execution, all work will need to be redone from the beginning. The DAS development team will be adding check-pointing to the system at a later point. When check-pointing is added, the system will note which phase of the top-down algorithm executed last and it will restart execution at that point.

The system has a growing number of self-tests that are executed using the Python “py.test” framework. These tests will check both the code and the execution environment. The “py.test” will be run by the DAS prior to the start of the top-down algorithm, so that failures can be rapidly detected and diagnosed.

DAS is developing a framework for recording and alerting on out-of-memory or out-of-storage conditions.

DAS is based on Python 3.6 and will be tested with Python 3.7 when available. However, for the 2018 end-to-end test, DAS will be using Python 3.6.

DAS is based on Gurobi 7.5; version 8.0 is now available. DAS will be using version 7.5 for the end-to-end test and will move to version 8.0 in Q2 2019.

DAS assumes that the Gurobi license manager will be available. If the license manager is not available, or if a license is not available, the client code will retry until it is. A RETRY LIMIT is not currently specified.

##### performance engineering considerations

DAS system performance depends on the following considerations:

* File transfer performance from S3 to EMR
* Performance of EMR distributing Python tasks
* Performance of the Java-Python gateway
* Performance of the Gurobi optimizer
* File transfer performance from DAS back to S3

##### performance metrics

The DAS developers have developed a system for capturing the utilization of memory and CPU resources and matching them to individual runs of the DAS. The DAS developers will perform this by capturing per-process and per-CPU usage every 5 seconds using DFXML and aggregating the results on the DAS EMR MASTER node, then transferring those results to S3 storage bucket. Separately, each use of the Gurobi optimizer captivates CPU usage, CPU load, memory usage, and other process information. This is all used to monitor system performance and tune the use of Gurobi during development.

##### system platform and design

DAS utilizes Amazon EMR which is a managed cluster platform that simplifies running big data frameworks, such as Apache Hadoop and Apache Spark, on AWS to process and analyze vast amounts of data.

The central component of Amazon EMR is the cluster. A cluster is a collection of Amazon Elastic Compute Cloud (Amazon EC2) instances. Each instance in the cluster is called a node. Each node has a role within the cluster, referred to as the node type. Amazon EMR also installs different software components on each node type, giving each node a role in a distributed application like Apache Hadoop.

**The node types in Amazon EMR are as follows:**

* **Master node**: A node that manages the cluster by running software components to coordinate the distribution of data and tasks among other nodes—collectively referred to as slave nodes—for processing. The master node tracks the status of tasks and monitors the health of the cluster.
* **Core node**: A slave node with software components that run tasks and store data in the Hadoop Distributed File System (HDFS)[[5]](#footnote-5) on the cluster.
* **Task node:** A slave node with software components that only run tasks. Task nodes are optional.

Figure 3: EMR Cluster Diagram

EMR Cluster Diagram.

# 9 API INTERFACE BUSINESS PURPOSE

The business purpose for this data exchange is to support privacy controls to microdata in the data flow from the Census Edited File (CEF) to the Microdata Detail File (MDF). The CDL platform will serve as a storage mechanism for the Disclosure Avoidance System. The Disclosure Avoidance System (DAS) to CDL interface is necessary in order for DAS to successfully complete its processing and write non-Title 13 data back to the Census Data Lake.

##### interface responsibilities

The interface includes a one directional flow of data from the Disclosure Avoidance System to the CDL. The DAS is responsible for providing the MDF to the CDL to allow for microdata tabulation. This interface will be executed using the SOA Managed File Transfer (MFT) process. The MDF file is structured as 2 tables for each of the 50 states, DC and PR.

##### The 2018 E2E mdf delivery consists of two pipe-delimited ascii text files:

* MDF\_UNIT.txt
* MDF\_PER.txt

##### disclosure avoidance - cdl data

The MDF was delivered from the DAS to the CDL in the form of pipe-delimited ASCII text files. DAS delivered the pipe-delimited ASCII files (2 tables for each state) to S3 using Spark. These "files" will appear as directories containing multiple parts. Spark convention is to designate parts as part-0001, part-0002, etc. The program **s3cat.py** located in **das\_decennial** then used an AWS S3 API to combine these files into a single file that could be moved back to the CDL.

##### boundary data structure

The MDF will be delivered from the DAS to the CDL in the form of pipe-delimited ASCII Text files.

Table 9: Boundary Data Structure Details

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Structure Unique Identifier** | **Name** | **Data Structure Characterization** | **Unique Identifier of Data Elements** | **Relationship (Order)** | **Exchange Format** |
| MDF.Person | Microdata Detail File (MDF) Person Data | *Non Title 13* | *MDF.PersonData* | n/a | *Pipe-delimited ASCII* |
| MDF.Unit | Microdata Detail File (MDF) Unit Data | *Non Title 13* | *MDF.UnitData* | n/a | *Pipe-delimited ASCII* |

For Boundary Data Structure see MDF Specs in Architecture section.

##### performance considerations

The 2018E2E MDF delivery will consist of two pipe-delimited ASCII text files: MDF\_UNIT.txt and MDF\_PER.txt. The two text files will be less than 2GB in size. Files will only be transferred once unless file transfer issues occur. The DAS team will check for file transfer failures, by utilizing the SOA Trace Monitoring API.

# 

# 10 ACRONYMS

Table 10: Acronyms

|  |  |
| --- | --- |
| **Acronym** | **Meaning** |
| **ACSO** | American Community Survey Office |
| **AES** | Advanced Encryption Standard |
| **AIAN** | American Indian or Alaska Native |
| **AMI** | Amazon Machine Image |
| **AWS** | Amazon Web Services |
| **CED-DA** | Center for Enterprise Dissemination - Disclosure Avoidance |
| **CEF** | Census Edited File. CEF processes the CUF, the tabulation geography table, and produces tables of edited data |
| **CDL** | Census Data Lake |
| **CIS** | Center for Internet Security |
| **CUF** | Census Unedited File, consisting of tables that are an input to the CEF |
| **CMK** | Customer Master Key |
| **DAS** | Disclosure Avoidance System |
| **DCMD** | Decennial Census Management Division |
| **DITD** | Decennial Information Technology Division |
| **DSEPC** | Data Stewardship Executive Policy Committee |
| **DP** | Differential Privacy |
| **E2E** | End-to-End |
| **EBS** | Elastic Block Store |
| **EC2** | Elastic Compute Cloud |
| **EMR** | Elastic Map Reduce |
| **GQ** | Group Quarters |
| **HDFS** | Hadoop Distributed File System |
| **IPT** | Integrated Project Team |
| **KMS** | Key Management Service |
| **MDF** | Microdata Detail File |
| **MDNH** | multi-dimensional national histogram |
| **MFT** | Managed File Transfer |
| **NHPI** | Native Hawaiian or Other Pacific Islander |
| **POP** | Population Division |
| **RPO** | Response Processing Operation |
| **TEA** | Type of Enumeration Area |
| **TI** | Technical Integration |
| **TSD** | Technical Specification Document |
| **S3** | Simple Storage Service |
| **SEHSD** | Social, Economic, Housing and Statistics Division |
| **SSE** | Server-Side Encryption |
| **SNS** | Simple Notification Service |
| **SOR** | Some Other Race or Ethnicity |

1. See *Disclosure Avoidance Techniques Used for the 1970 through 2010 Decennial Censuses of Population and Housing*, Laura McKenna, October 2018, Center for Economic Studies Working Paper 18-47, US Census Bureau, available at [https://www2.census.gov/ces/wp/2018/CES-WP-18-47.pdf](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=2ahUKEwj2g6OzzZPhAhWPtlkKHVRJBIMQFjAEegQILBAC&url=https%3A%2F%2Fwww2.census.gov%2Fces%2Fwp%2F2018%2FCES-WP-18-47.pdf&usg=AOvVaw21doWQ60fjuwBnseqEajVE). [↑](#footnote-ref-1)
2. <https://www.census.gov/programs-surveys/decennial-census/about/why.html> [↑](#footnote-ref-2)
3. Note: for historical reasons, the term *disclosure avoidance* is used at the US Census Bureau to describe statistical disclosure limitation; that term will be used in the remainder of this document. [↑](#footnote-ref-3)
4. Puerto Rico is processed using the same DAS, but is given a separate privacy loss budget and is not included in totals labeled “United States.” [↑](#footnote-ref-4)
5. DAS currently does not use HDFS. [↑](#footnote-ref-5)