.[1] **For this project's specific needs—focusing on contract awards within a defined timeframe and set of states—the Custom Award Data download feature is the most appropriate method.**[9]

The Award Data Archive provides full fiscal year datasets for major agencies but offers less flexibility for filtering across multiple specific states or custom date ranges upfront.[7] Custom Account Data includes non-award spending like salaries and operational costs, which is broader than the project's scope focused on contracts.[8]

The Custom Award Data download page allows users to precisely tailor their data request.[9] Key advantages for this project include the ability to filter by:

- **Award Type:** Users can specifically select "Contracts" under the "Prime Awards" category, ensuring the downloaded data pertains only to federal contracts and excludes grants, loans, direct payments, and other financial assistance.[9] Sub-awards can also be selected but are secondary to the prime contract focus of the proposal.
- **Date Range:** The interface permits selecting a custom date range. To cover FY 2019-2024, the user would typically select a start date of October 1, 2018, and an end date covering the latest available data in 2024. It is important to note that the Custom Award Data download interface may limit individual downloads to a one-year span at a time.[9] If this limitation exists, multiple downloads (one for each fiscal year or calendar year within the range) will be necessary, requiring subsequent merging of the resulting files. The action_date field should be used as the Date Type for filtering.[9]
- **Location:** Crucially, filtering by "Recipient Location" allows the selection of specific states.[9] The project requires data for Virginia, California, and Maryland. While specific interface elements for multi-state selection were not detailed in the provided materials [9], the Advanced Search functionality [11] and the Custom Award Data form [9] clearly indicate location filtering capabilities. Users should verify on the live site if multiple states can be selected in a single download request or if separate downloads per state are needed.
- **File Format:** CSV (Comma Separated Values) is recommended as the output format due to its wide compatibility with various data analysis tools and programming languages like Python and R.[9]

The direct link to the Custom Award Data download page is: https://www.usaspending.gov/download_center/custom_award_data.[9]

B. Understanding Data Structure and Key Fields

The downloaded data will likely be at the *award transaction* level. It is important to understand the distinction between transactions and summaries.[10] A prime award transaction represents a single action, such as the initial awarding of a contract or a subsequent modification (e.g., adding funds, changing the scope). A prime award summary, conversely, is an aggregation or roll-up of all transactions that belong to the same overall award, identified by a unique award key (award_unique_key or contract_award_unique_key).[10] For analyzing spending flows, sector distributions, and temporal trends based on when funds were committed, working with the transaction-level data is generally preferable, allowing for aggregation based on specific analytical needs (e.g., summing obligations by fiscal year, agency, and state).

Extracting the correct data fields is paramount. The USASpending Data Dictionary provides authoritative definitions.[12] Based on the project's analytical goals, the following fields are essential:

Table 1: Essential Data Fields for Federal Contract Analysis (VA, CA, MD)

Analytical Need	**USASpending Field Name (Likely)**	**Definition Snippet/Source**	**Typical File Type**
Recipient State	recipient_location_state_code	State code where the recipient entity is located. [9]	Contract Award Files
Place of Performance	place_of_performance_state_code	State code where the contracted work is performed. [2]	Contract Award Files
Awarding Agency	awarding_agency_name, awarding_sub_agency_name	Name of the primary awarding agency and sub-tier agency. [3]	Contract Award Files
Contract Value	federal_action_obligation	Amount obligated by the federal government for a specific transaction. Represents the primary measure of spending value for analysis. [1]	Contract Award Files

Date Awarded	action_date	The date the contract action (award, modification) was signed. Most relevant for tracking *when* funds were committed. [9]	Contract Award Files
Period of Performance	period_of_performance_start_date, period_of_performance_current_end_date	Start and end dates for the work performed under the contract. [12]	Contract Award Files
Industry Sector (NAICS)	naics_code, naics_description	North American Industry Classification System code and description, identifying the industry sector. [2]	Contract Award Files
Product/Service (PSC)	product_or_service_code, product_or_service_code_description	Code identifying the specific product or service procured. [2]	Contract Award Files
Recipient Name	recipient_name	Name of the company/entity receiving the contract award. [1]	Contract Award Files
Unique Award Identifier	award_unique_key, contract_award_unique_key	Unique identifier for the overall award summary (aggregates transactions). Useful for linking related transactions. [10]	Contract Award Files
Unique Entity ID (UEI)	recipient_uei	Unique identifier for the recipient entity (replaced DUNS). Useful for identifying	Contract Award Files

		unique companies. [6]	
Recipient ZIP Code	recipient_location_zip_code	ZIP code of the recipient's location. Needed for sub-state geographic mapping. [12]	Contract Award Files
Place of Performance ZIP	place_of_performance_zip_code	ZIP code where work is performed. Needed for sub-state geographic mapping based on activity location. [12]	Contract Award Files

A crucial consideration arises when choosing between recipient_location_state_code and place_of_performance_state_code. The former identifies the state where the company receiving the funds is based, aligning well with analyzing state-based industry strengths (like VA's defense sector or CA's tech sector). The latter indicates where the actual contract work is performed, which might better reflect the geographic distribution of economic activity stemming from the contract. For instance, a large defense contractor headquartered in Virginia might perform work on a contract in California. Analyzing by recipient location would attribute the funds to VA, while analyzing by place of performance would attribute them to CA. Given the project's focus on state-specific industry characteristics, recipient_location_state_code appears primary, but acknowledging or even incorporating place_of_performance_state_code could provide valuable context about where the contracted activities are geographically dispersed. The analysis should clearly state which location field is being used for primary state assignment.

For quantifying contract value, federal_action_obligation is the standard field.[1] This represents the amount of money the government legally committed for a specific contract action. While outlay data represents actual payments made, obligations are the conventional measure for tracking awarded contract amounts and aligning with budget commitments.[1] Summing federal_action_obligation across relevant transactions (e.g., within a fiscal year for a specific state and agency) will provide the total contract values needed for the visualizations.

For temporal analysis tracking when contracts were awarded or modified within the FY 2019-2024 period, the action_date field is the most appropriate.[9] This field captures the date the specific contractual action was signed. The period_of_performance_start_date, while relevant for understanding project timelines, does not reflect the timing of the award commitment itself.[12] Therefore, filtering and aggregating data based on action_date is necessary to accurately analyze trends in contract awards over the specified fiscal years.

C. Data Dictionaries and Metadata

Thoroughly understanding the precise meaning, format, and potential nuances of each data field is critical for accurate analysis

- **Online Data Dictionary:** Provides web-based access to definitions and details for data elements found in downloads.[2] Link: https://www.usaspending.gov/data-dictionary
- **Dataset Metadata:** A JSON file describing the properties of datasets published on USAspending.gov.[4]

III. Recommended Visualization Strategies

A. Geographic Distribution (Contracts within VA, CA, MD)

- **Goal:** Visualize the concentration and distribution of contract awards (by value or count) within the geographic boundaries of Virginia, California, and Maryland.
- **Evaluation:**
  - **Choropleth Maps:** These maps use color intensity to represent data values aggregated within predefined geographic boundaries, such as counties or ZIP code tabulation areas (ZCTAs).[17] They provide a good overview of spatial patterns across a state. However, they can sometimes be misleading if the geographic areas vary significantly in size, as larger areas might draw undue attention regardless of their data value.[19] They also require aggregating the contract data (e.g., summing federal_action_obligation by county) and obtaining corresponding geospatial boundary files (shapefiles or GeoJSON).
  - **Point/Bubble Maps:** These maps place a marker (point) at a specific location associated with each data record, such as the recipient's ZIP code centroid.[19] In a bubble map variation, the size of the marker is scaled proportionally to a data value, like total contract obligation.[19] These maps excel at showing precise locations and highlighting clusters or density. However, they can become visually cluttered in areas with high data density (e.g., Northern Virginia near D.C., the San Francisco Bay Area, the Baltimore-Washington corridor).[19] Overlapping bubbles can obscure underlying data points. Effective use requires reliable sub-state location data (like recipient_location_zip_code or place_of_performance_zip_code) and potentially geocoding capabilities. Interactive features like zooming and panning can help mitigate clutter.[18]

Cluster maps, which aggregate nearby points into larger symbols at higher zoom levels, are another technique to manage density but add implementation complexity.[19]

- **Recommendation:** A combination approach is recommended. Start with **county-level choropleth maps** for each state (VA, CA, MD), colored by total federal_action_obligation or number of contract actions. This provides an accessible overview of broad regional distribution. Supplement this with **interactive bubble maps**, plotting recipient locations (derived from ZIP codes) where the bubble size represents the total contract value awarded to recipients in that ZIP code. Interactivity (zoom, pan, tooltips showing details on hover) will be crucial for managing potential clutter in dense areas. This dual approach balances the need for a high-level summary with the ability to explore more granular patterns.
- **Consideration:** The feasibility of detailed sub-state mapping hinges entirely on the quality and availability of ZIP code or county information within the downloaded USASpending data. An initial data exploration step must verify the completeness and reliability of the recipient_location_zip_code, recipient_location_county_code, place_of_performance_zip_code, and place_of_performance_county_code fields. If only state-level information is consistently reliable, the geographic analysis will be limited to state-level comparisons rather than intra-state distributions.

B. Agency-to-State Funding Flows

- **Goal:** Illustrate the magnitude of contract funding flowing from major federal awarding agencies to recipients located in Virginia, California, and Maryland.
- **Evaluation:**
  - **Sankey Diagrams:** These are flow diagrams where nodes represent categories (in this case, federal agencies and the three states) and the thickness of the connecting links (flows) is proportional to the quantity being visualized (total federal_action_obligation).[23] Sankey diagrams are exceptionally effective at showing distribution, proportions, and flow between distinct stages or entities.[23] They are particularly well-suited for visualizing budget allocations and financial flows, as demonstrated by existing government spending visualizations.[26] A potential drawback is that they can become visually complex if too many nodes (agencies) are included.
  - **Flow Maps / Chord Diagrams:** These visualizations also show connections between entities, often arranging them radially.[29] The thickness or weight of arcs between entities represents the flow volume. While visually distinct and capable of showing many-to-many relationships, interpreting the precise

magnitude of flows can sometimes be less intuitive than with a Sankey diagram, especially for straightforward source-to-destination patterns like agency-to-state funding.

- **Recommendation:** A **Sankey Diagram** is highly recommended for this task. It directly visualizes the flow of funds from source (awarding agency) to destination (recipient state). To maintain clarity and avoid excessive visual clutter, the diagram should be filtered to display flows from the top N awarding agencies (e.g., the top 10 or 15 agencies based on total obligations across the three states, or perhaps the top 5-7 agencies for *each* state). This will effectively highlight the primary sources of federal contract funding for VA, CA, and MD and their relative importance.

C. Sector/Industry Breakdown by State (NAICS)

- **Goal:** Compare the composition of federal contract awards across different industry sectors, as defined by the North American Industry Classification System (NAICS), within and between Virginia, California, and Maryland.
- **Evaluation:**
    - **Stacked Bar Charts:** These charts use bars (typically one per state) divided into segments representing different NAICS sectors.[30] The height of each segment corresponds to the contract value in that sector. A 100% stacked bar chart shows the relative proportion of each sector within a state's total contract value. Stacked bars effectively show the part-to-whole composition for each state.[31] However, comparing the absolute value of a specific sector *across* states can be challenging unless that sector forms the base of the stack. Too many segments can also lead to clutter.
    - **Grouped Bar Charts:** These charts place bars representing different categories (NAICS sectors) side-by-side for each group (state), or vice versa.[17] This format excels at direct comparison of a specific sector's value across the three states.[31] However, it makes it harder to visually grasp the total contract value for each state at a glance.
    - **Treemaps:** These use nested rectangles where the area of each rectangle is proportional to the contract value.[30] They can effectively display hierarchical data (like NAICS sectors and sub-sectors) and show the dominance of certain categories within a limited space.[36] However, precise comparison of values between rectangles, especially non-adjacent ones or across different treemaps (if used per state), can be difficult.
- **Recommendation:** Employ **Faceted Grouped Bar Charts**. One effective approach is to group bars by the top N NAICS sectors (e.g., top 10-15 based on total value across VA, CA, MD). Within each sector group, display three bars

representing the total obligated value for VA, CA, and MD, allowing direct comparison of that sector's funding across states. Faceting by sector (i.e., creating a small chart for each sector showing the three states) is another way to organize this.[20] This design facilitates both within-state assessment of sector importance relative to others and cross-state comparison for specific industries. Complementing this with **faceted 100% stacked bar charts** (one per state, showing sector proportions) can effectively highlight the relative industry focus within each state (e.g., confirming VA's defense concentration or CA's tech focus).
- **Consideration:** NAICS codes offer a hierarchy, from broad 2-digit sectors (e.g., 54 - Professional, Scientific, and Technical Services; 31-33 - Manufacturing) down to specific 6-digit industries.[2] Visualizing at the 6-digit level would likely be overwhelming. Aggregating contract values to the 2-digit NAICS sector level provides a manageable number of categories suitable for high-level comparison, aligning with the project's goal of identifying broad sectoral differences. If using interactive tools, features like tooltips or drill-down capabilities could be implemented to allow users to explore the specific industries contributing to each major sector's total.

D. Temporal Trends (FY 2019-2024)

- **Goal:** Display how the total value or number of federal contract awards has changed over the fiscal years 2019 through 2024 for each of the three focus states.
- **Evaluation:**
    - **Line Charts:** These plots are ideal for showing trends, fluctuations, and patterns over continuous intervals like time.[17] Plotting time (fiscal year, or potentially quarter for more granularity) on the x-axis and the metric (total federal_action_obligation or contract count) on the y-axis, with separate lines for VA, CA, and MD, allows for easy comparison of temporal trajectories.
    - **Area Charts:** Similar to line charts, but the area between the line and the baseline is filled, emphasizing the volume or magnitude of the metric over time.[30] Stacked area charts layer multiple series (e.g., contributions of top agencies or sectors) cumulatively, showing how the composition of the total changes over time.[30] While effective for showing cumulative totals, stacked versions can sometimes obscure the trends of individual components if layers overlap significantly or if lower layers fluctuate wildly.
- **Recommendation:** Utilize a **multi-line chart** as the primary visualization to compare the overall trend of total obligated contract dollars for Virginia, California, and Maryland across FY 2019-2024.[29] Time should be plotted on the x-axis (using fiscal year or quarter, derived from action_date), and total

federal_action_obligation on the y-axis. Consider adding annotations to mark potentially significant events, such as the onset of major COVID-19 related spending (which could be identified using Disaster Emergency Fund Codes (DEFCs) if included in the analysis [8]). To provide deeper insight into *how* spending composition evolved, supplement the main line chart with **faceted stacked area charts**. Create one stacked area chart per state, showing the total obligation trend over time, with the area divided (stacked) by the top 3-5 awarding agencies or top 3-5 NAICS sectors for that state. This will visualize shifts in funding sources or industry focus within each state over the period.[30]

E. State Comparison (VA vs. CA vs. MD)

- **Goal:** Enable direct comparison of key federal contracting metrics across Virginia, California, and Maryland.
- **Evaluation:**
  - **Grouped Bar Charts:** An effective and straightforward way to compare discrete values across categories.[17] Use groups of bars to compare metrics like total contract value [39], average contract value, total number of contract actions, or spending in specific key sectors (e.g., comparing NAICS 54 vs. Defense-related NAICS) side-by-side for VA, CA, and MD.
  - **Faceted Charts (Small Multiples):** Displaying the same type of chart (e.g., a bar chart showing the top 10 recipients, or a histogram of contract values) separately for each state allows for easy comparison of patterns, distributions, or rankings across the states.[20] This maintains clarity for each state's individual profile while facilitating comparison.
  - **Box Plots (Box-and-Whisker Plots):** These plots summarize the distribution of a numerical variable.[17] Comparing box plots of individual federal_action_obligation values for each state can reveal differences in the typical size, spread (interquartile range), and presence of outliers in contract awards, going beyond simple totals or averages.
- **Recommendation:** Use **grouped bar charts** for comparing aggregate summary metrics (e.g., total FY 2019-2024 obligation, average obligation per action, total obligations in NAICS 54). Use **faceted histograms or box plots** to compare the distribution of individual contract action values (federal_action_obligation) across the three states.[20] This comparison of distributions is important because states might achieve similar total values through very different means – one state might rely on numerous smaller contracts, while another depends on a few very large ones. Visualizing this distribution adds significant explanatory power. Consider including a summary table alongside these comparative charts to provide precise numerical values for key metrics. Contextualizing these comparisons with external

benchmarks or findings, such as state rankings reported by GAO or other analyses [39], can further enrich the narrative.

IV. Effective Data Processing Techniques for Large Datasets

Analyzing federal contract data spanning multiple years for several states, especially at the transaction level, often involves handling large datasets that can exceed the memory capacity of a standard computer.[43] Implementing efficient data processing strategies is therefore essential.

A. Pre-processing and Filtering

Minimizing the amount of data loaded into memory is the first line of defense against performance issues.

- **Filter During Download:** As discussed in Section II.A, leverage the filters available in the USASpending.gov Custom Award Data download tool to retrieve only the necessary subset of data from the outset (i.e., only Contracts, only for VA/CA/MD, only for FY 2019-2024).[9] This avoids downloading irrelevant award types or time periods.
- **Load Only Necessary Columns:** When reading the downloaded CSV file(s) into your analysis environment (e.g., Python or R), explicitly specify only the columns required for the planned visualizations and analysis (as listed in Table 1). Loading unnecessary columns consumes significant memory.[44]
    - In Python with Pandas, use the usecols parameter within the pd.read_csv() function.[44]
    - In R with data.table, use the select parameter within the fread() function.[45]
- **Optimize Data Types:** Pandas and R often default to memory-intensive data types (e.g., 64-bit floats or integers, object types for strings). Converting columns to more efficient types after loading (or sometimes during loading) can drastically reduce memory footprint.[44]
    - For text columns with a limited number of unique values (e.g., state codes, agency names, potentially NAICS codes/descriptions), convert them to a category type in Pandas [44] or a factor in R. This stores each unique string only once, using integer codes internally to represent the values in the column.
    - For numeric columns, assess if the default precision is necessary. Integer IDs might fit into smaller integer types (like uint16, uint32, int32). Floating-point numbers (like federal_action_obligation) might be adequately represented by float32 instead of float64, halving the memory usage for that column. Use functions like pd.to_numeric() with the downcast argument in Pandas [44] or appropriate as.* functions in R.

- **Process in Chunks:** If the dataset remains too large for memory even after column selection and type optimization, process the data in manageable chunks.[44] Read the input file piece by piece, perform necessary calculations or aggregations on each chunk (e.g., calculating sums or counts per group), and then combine the intermediate results to get the final answer.
    - In Python with Pandas, the chunksize parameter in pd.read_csv() facilitates this iterative processing.[44]
    - In R, libraries like chunked [49] or strategies involving reading specific line ranges with fread (nrows, skip) [45] can be used, although database approaches are often preferred for more complex chunk-based workflows in R.[48]

B. Tool Assessment

- **D3.js (Data-Driven Documents):** [21]
    - *Assessment:* D3.js is a JavaScript library offering unparalleled power and flexibility for creating bespoke, interactive data visualizations for the web. It allows manipulation of document objects (HTML, SVG, Canvas) based on data, enabling virtually any visual design imaginable.[59] This makes it ideal for achieving novel and highly engaging results. However, this power comes at the cost of a steep learning curve [60] and requires strong proficiency in JavaScript, HTML, SVG, and CSS. Development can be time-consuming as developers often need to build chart components from low-level primitives, essentially "reinventing the wheel" compared to higher-level libraries.[61] While the code *can* be clean and documented, the complexity increases the risk of disorganized code if not carefully managed.
    - *Rubric Fit:* Very High potential for Novelty and Engagement. Lower score on ease of achieving Polish and Clean Code without significant expertise and effort. Problem-solution fit is high if custom visuals are needed, but overkill for standard charts. Presentation structure depends on surrounding web development. Code is inherently publishable (web).
- **Tableau (and Tableau Public):** [22]
    - *Assessment:* Tableau is a leading commercial business intelligence tool focused on rapid creation of interactive dashboards and standard visualizations through a drag-and-drop interface.[61] It excels at data exploration and creating polished dashboards quickly. Tableau Public allows free sharing of visualizations and dashboards online.[67] However, its strength in ease-of-use comes with limitations in customization for truly novel designs.[61] As a primarily GUI-driven tool, producing shareable, version-controlled code

that fully reproduces the visualization is difficult or impossible.[66] Furthermore, data uploaded to Tableau Public is not private.[68]

- *Rubric Fit:* High on Polish and Clarity (for dashboards). Moderate on Engagement (standard interactivity). Low on Novelty and critically low on the Clean/Documented/Published Code requirement.
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- Sites to get Data

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