



Beyond the Motor City: Benchmarking the Detroit Region's Software-Defined Vehicle Future

Performed for:

**The Global Epicenter of Mobility, a signature program
led by the Detroit Regional Partnership**

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Appendix A. Methodology and Data Sources

A.1 Purpose and Overview

The analysis presented by TEconomy Partners, LLC (TEconomy) in this briefing examines recent innovation activity related to Software-Defined Vehicle (SDV) technologies using three complementary indicators: venture capital investment, federal Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) awards, and industry-assigned patent records. Together, these indicators capture different stages of the innovation pipeline, from early research and development through commercial scale-up and protected intellectual property.

For the purposes of this briefing, the “Detroit Region” is defined as the eleven-county area served by the Detroit Regional Partnership: Shiawassee, Genesee, Lapeer, St. Clair, Livingston, Oakland, Macomb, Washtenaw, Wayne, Lenawee, and Monroe. All references to regional venture-backed companies, SBIR/STTR awards, and patenting activity are bounded by this 11-county geography.

The analysis covers activity from the start of 2021 through the latest available data, often Q2 2026, in order to capture recent post-Covid market developments, including the early adoption of generative AI and other advanced analytics and software technologies. To ensure consistency across datasets, this analysis applied a common, stack-based definition of SDV technologies and a multi-stage filtering process designed to identify innovation genuinely aligned with the SDV technology stack while excluding adjacent activity in general automotive hardware, generic semiconductor design, or software development without a specific SDV application.

A.2 SDV Technology Stack Definition

Defining the boundaries of what counts as an SDV-relevant technology is a challenging exercise, as the term “software-defined vehicle” itself lacks a single universally adopted definition. Industry stakeholders – including OEMs, Tier 1 suppliers, semiconductor firms, software developers, and policymakers – apply the concept with varying scope depending on their position in the value chain, and published frameworks differ in how they slice and name stack layers.

To provide a consistent and operationally defensible basis for identifying relevant innovation activity across the three data sources used in this analysis, TEconomy



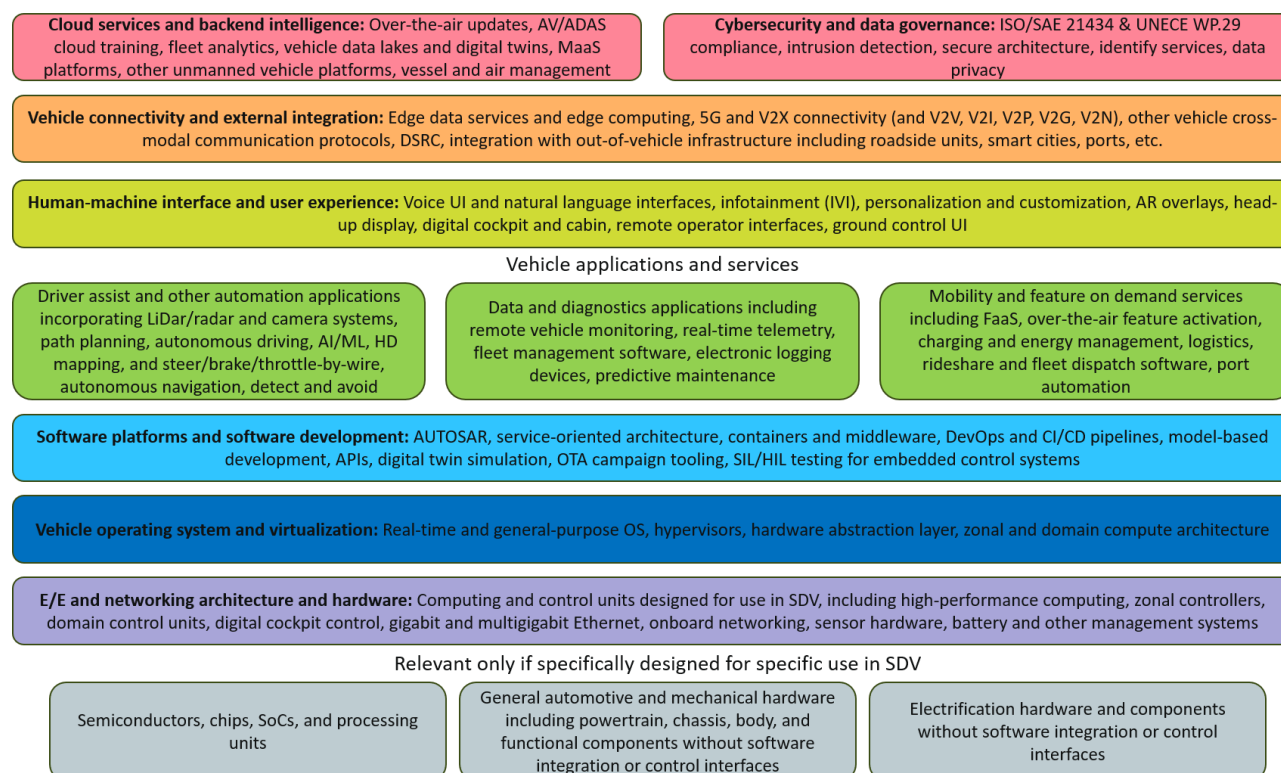
conducted a structured review of published SDV technology-stack frameworks across OEM and supplier technical publications, automotive software architecture literature, and emerging standards discussions, and synthesized those descriptions against regional intelligence from the DRP-GEM Future Mobility Technology Study (FMTS) and Advanced Driver-Assistance Systems (ADAS) Study. The final technology-stack taxonomy organizes the SDV innovation landscape into seven principal layers:

- 1. Electrical and electronic hardware** – The physical foundation of the SDV, including high-performance centralized computers, zonal control units, digital cockpit electronics, high-speed data cabling, sensors, batteries, and energy management systems increasingly controlled by software.
- 2. Vehicle operating system and virtualization** – The “software engine room” enabling safe and reliable vehicle software operation, including core operating systems, real-time scheduling, virtualization technologies allowing multiple software environments to share hardware, and architectural patterns that isolate functions for update, restart, or security.
- 3. Software platforms and development tools** – Shared services and tooling that developers use to build, test, deploy, and update vehicle software, including middleware, packaging and deployment tools, continuous delivery pipelines, and testing and simulation environments.
- 4. Vehicle applications and services** – Driver- and fleet-facing functions such as advanced driver-assistance systems (ADAS), autonomous driving features, high-definition mapping, and software-controlled steering, braking, and acceleration.
- 5. Human-machine interface and user experience** – In-vehicle and remote user interaction layers, including voice controls, natural language understanding, infotainment, personalization, augmented reality displays and head-up displays, and remote operator stations for unmanned vehicles.
- 6. Vehicle connectivity and integration with the outside world** – Communication backbones such as 5G connectivity, vehicle-to-everything (V2X) communications with other vehicles, infrastructure, pedestrians, and the grid, edge computing systems, and integration with smart city and port infrastructure.
- 7. Cloud services, backend intelligence, and cybersecurity** – Off-vehicle command and control environments supporting OTA software updates, cloud-based training of autonomy and ADAS algorithms, fleet data analytics and digital twins, mobility service platforms, and cross-cutting cybersecurity and data governance functions.

This seven-layer taxonomy provided the operational basis for identifying technologies particularly aligned with the SDV space and ensured that findings are consistently bounded by a common definition of SDV-relevant innovation activity. (Figure 1)



Figure 1. Taxonomy of the SDV Technology “Stack” Used to Frame this Study



Source: TEconomy analysis

A.3 Data Sources

The analysis relies on three major datasets that together provide complementary indicators of SDV innovation:

- **Venture capital data** – PitchBook records on U.S. venture-backed companies, including deal counts, invested capital, company descriptions, industry/vertical tags, and firm metadata.
- **Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) data** – SBIR.gov records on SBIR and STTR awards since 2021, including agency, program phase, award amount, and detailed project abstracts and descriptions.
- **Patent data** – USPTO patent information accessed via Derwent Patent Analysis, including both applications and issued patents, Cooperative Patent Classification (CPC) codes, abstracts, claims, and assignee information.

Each dataset uses a different unit of analysis (company, award, patent record) and captures a different stage of the innovation pipeline, which is why they are combined rather than used in isolation.

A.4 Identifying SDV-Relevant Records

Identifying the relevant universe of companies, patent records, and SBIR awards required a systematic, multi-stage process designed to capture innovation genuinely relevant to the SDV technology stack while excluding adjacent activity. Each dataset applied a staged approach to filter down to SDV-aligned records from a broader universe of potentially related activity. (Figure 2)

Venture-backed companies

- TEconomy began with 28,906 venture-backed companies tagged with industries, sectors, or verticals potentially related to the SDV technology stack in PitchBook.
- This universe was reduced to 14,236 companies through keyword matching against curated lists derived from the SDV technology-stack taxonomy.
- A text-embedding classifier was then used to assess company descriptions, products, and services for semantic alignment with SDV-relevant technologies, further filtering the set.
- Targeted company website reviews were conducted to validate borderline cases, yielding a final set of 1,889 SDV-related venture-backed companies.

Patent records

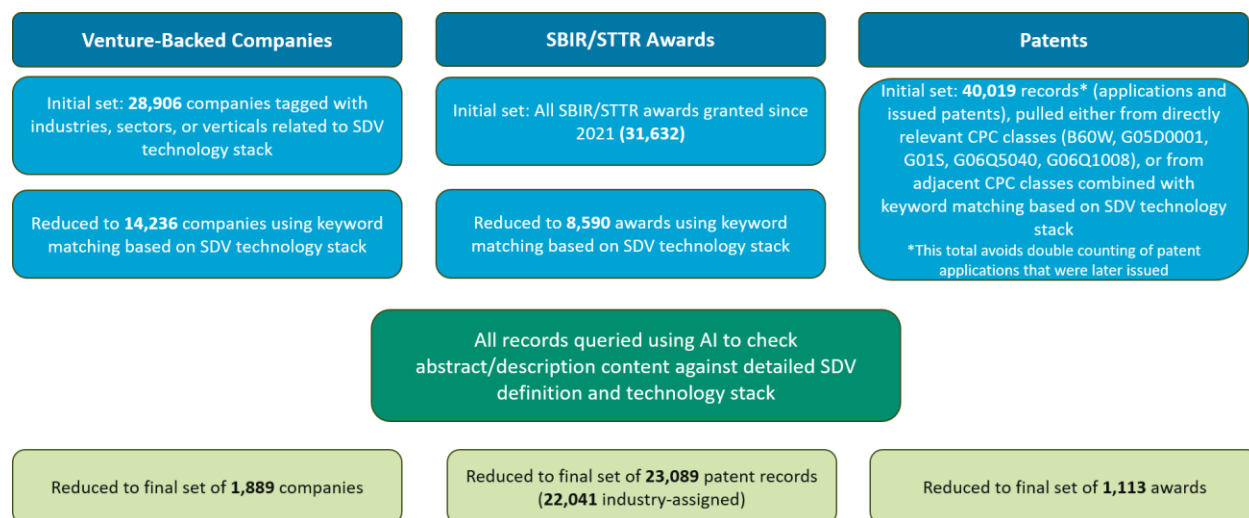
- TEconomy assembled an initial universe of 40,019 patent records (applications and issued patents) from CPC classes directly relevant to core SDV, ADAS, and other technologies, plus adjacent classes identified via taxonomy-based keyword matching.
- Records were deduplicated to avoid counting patent applications that were subsequently issued as granted patents.
- A text-embedding classifier based on abstract and description content, calibrated against the detailed SDV definition and technology stack, yielded a final set of 23,089 SDV-relevant patent records.
- Of these, 22,041 industry-assigned records formed the primary basis for geographic and company-level analysis.

SBIR/STTR awards

- TEconomy began with all 31,632 SBIR and STTR awards granted since 2021 from SBIR.gov.
- Keyword matching against the SDV technology-stack taxonomy reduced this universe to 8,590 awards.
- A text-embedding classifier applied to award abstracts and project descriptions produced a final set of 1,113 unique SDV-relevant projects.



Figure 2. Methodology for Collection and Refinement of Data on Market Signals of SDV-related Innovation from 2021 to Present



Source: TEconomy analysis

A.5 Natural Language Processing and Thematic Clustering

To understand detailed technology themes and application domains within each dataset, TEconomy applied a natural language processing pipeline to unstructured text content.

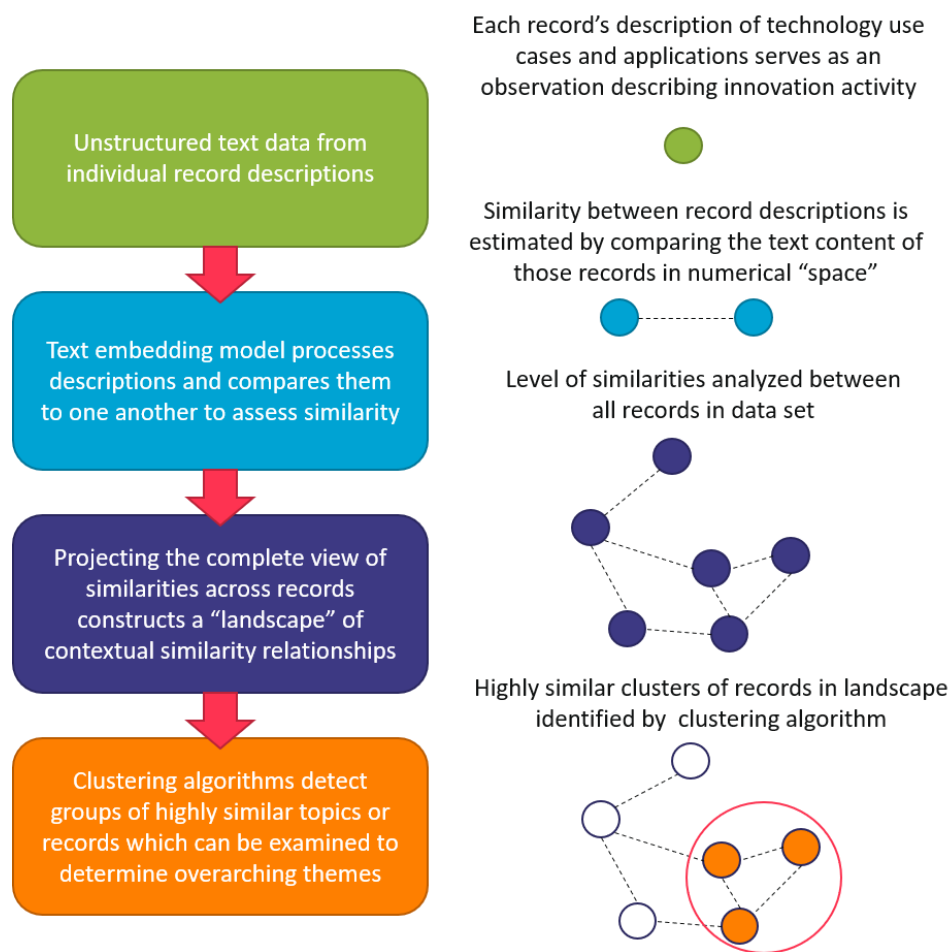
A.5.1 Text Embedding

For each record, relevant descriptive text fields were converted into higher-dimensional numerical embeddings, where geometric distance between any two records reflects semantic similarity in subject matter. The specific text fields used varied by dataset:

- **Venture-backed companies:** PitchBook company descriptions were enriched with additional text mined from company websites describing key products and services, using keyword identification algorithms and generative AI summarization.
- **SBIR/STTR awards:** Detailed award abstracts and project descriptions from SBIR.gov were used as the primary text source.
- **Patent records:** Patent abstracts and claims descriptions from USPTO were analyzed, with similarities further enriched by weighting text-embedding similarities with cosine similarities between CPC technology class combinations.

This processing produced a complete matrix of pairwise similarity relationships across all records in each dataset, capturing how closely related each company, award, or patent is to every other in terms of technology focus and application domain, without requiring a predefined taxonomy for grouping. (Figure A-1)

Figure A-1. TEconomy's Approach to Examining Detailed Innovation Themes Within Unstructured Text Data



A.5.2 Landscape Construction and Clustering

The similarity matrices were projected into two-dimensional “landscapes” in which:

- Records describing closely related technologies and use cases are positioned near one another.
- Records addressing distinct areas of the SDV stack or different application domains are positioned farther apart.

A clustering algorithm and community-detection methods were then applied to each landscape to identify groups of highly interrelated records, defining the thematic clusters visible in the report’s figures. TEconomy analysts interpreted and labeled each cluster based on its constituent records, producing the thematic descriptions for areas such as:

- Advanced sensing, imaging, and 3D perception platforms.
- Wireless communications, localization, and navigation.
- Autonomy navigation, orchestration, and digital-twin platforms.
- Drone, UAV, and aircraft software platforms.

- Autonomous maritime fleet intelligence and subsea robotics.
- Computing, software, and data infrastructure for driver assistance, cybersecurity, connectivity, predictive maintenance, and telematics.

For SBIR/STTR awards, clusters highlighted defense-oriented and safety-critical SDV themes such as autonomous UAV and UGV logistics and security systems, aircraft design and electrification, resilient autonomy in GPS-denied environments, and networked communications and cybersecurity for UAS, ground, and naval platforms. For patents, clusters spanned LiDAR-based perception and localization, integrated multi-sensor perception stacks, AI-enabled vehicle autonomy, air and rail autonomy management, multi-vehicle orchestration platforms, cabin intelligence, SDV platform and infrastructure, and intelligent charging and energy routing.

This approach allows the structure of each dataset's thematic landscape to emerge organically from record content rather than from a subjective pre-sorting and makes the relative density, scale, and proximity of thematic areas directly visible.

A.6 Mapping Activity to the SDV Stack

For synthesis across indicators, TEconomy mapped curated records back onto the seven-layer SDV technology stack and assessed relative levels of recent innovation activity by stack layer and indicator. For each stack element, activity was qualitatively ranked as exhibiting more limited, moderate, or strong innovation based on the density of venture-backed companies, SBIR/STTR awards, and industry-assigned patent records.

The resulting table (Table 1 in the report) ranks levels of recent innovation activity across layers such as cybersecurity and data governance; cloud services and backend intelligence; OTA vehicle connectivity and V2X; human-machine interface and UX; vehicle applications and services; software platforms and developer tools; vehicle OS and virtualization; and electrical/electronic networking hardware. Where all three indicators converge at high activity around a stack element, the evidence for strategic importance is strongest; where activity is concentrated in only one or two indicators, the innovation is more specialized (e.g., defense-oriented or primarily commercial).



Table 1. Ranking Levels of Recent Innovation Activity Within Elements of the SDV Technology Stack by Activity Type

SDV Technology Stack Layer	Venture Capital Investment	SBIR/STTR Awards	Patenting Activity
Cybersecurity & Data Governance	Moderate	Strong	Moderate
Cloud Services, Backend Intelligence & OTA	Strong	Limited	Strong
Vehicle Connectivity & V2X	Strong	Moderate	Strong
Human-Machine Interface & UX	Moderate	Limited	Strong
Vehicle Applications & Services (Autonomy, ADAS)	Strong	Strong	Strong
Software Platforms & Software Dev Tools	Moderate	Limited	Moderate
Vehicle OS & Virtualization	Moderate	Limited	Moderate
Electrical/Electronic & Networking Hardware	Moderate	Moderate	Strong

Source: TEconomy analysis and market research

A.7 Limitations and Mitigation Measures

Several methodological limitations are inherent in this approach:

- **Text dependence:** The methodology relies on the quality and specificity of text descriptions in databases and patent abstracts; sparse or generic descriptions may lead to under-capture of some SDV-relevant activity.
- **Taxonomy and keyword bias:** While the SDV stack taxonomy is grounded in literature and regional intelligence, any curated keyword list introduces some bias about what is considered “in scope.”
- **Classifier errors:** Machine-learning classifiers may occasionally misclassify borderline records, including adjacent technologies whose narrative framing overlaps with SDV concepts or excluding emerging SDV areas using novel terminology.

These limitations were mitigated through iterative calibration of keyword lists and classifiers, manual review of borderline cases (especially for venture-backed companies), and triangulation across three independent datasets to validate patterns. Where possible, results were interpreted qualitatively rather than as precise measures of total activity, focusing on relative strengths, gaps, and structural patterns.