The Science Behind Intelligent Automation

How Integrated Automation Systems (IAS) enable faster, more objective facility planning and cost modeling

Beyond the marvel and mystery of AI lies Intelligent Automation, a concrete, complexity science–based alternative to traditional building planning, design, and cost modeling and management.

This resource explains the scientific logic behind an Intelligent Automation System (IAS) for facility planning and cost management. For illustration purposes, this paper references Building CATALYST, a commercially available SaaS implementation of IAS.

What We Will Cover

- **Overview:** what IAS produces and what inputs it needs
- **IAS as a Deming-based system**
- **IAS and the scientific method**
- **Why systems-based standards matter**
- **Worked examples**
- **IAS as a “system of systems”**
- **Geo-location + escalation normalization**
- **Statistical variability:** why uncertainty persists in some systems
- **Deming’s goal:** resolving variation
- **AI-driven:** data mapping and translation
- **Conclusion:** proof through outcomes

What is IAS?

An **Intelligent Automation System (IAS)** is a planning and cost-modeling operating system that enables owners and/or teams to:

- model program, scope, schedule, and cost *from the earliest stages*
- run comparisons and options studies rapidly and consistently
- reduce uncertainty (variation) through structured inputs and iterative refinement
- keep humans in control while using computation to accelerate iteration

IAS is best understood as a hybrid of:

- BIM (as knowledge resource)
- Predictive analytics
- Design optimization
- AI (support layer, not replacement)

IAS matters because real estate development is expensive, complex, and highly sensitive to early decisions. A system that enables earlier clarity and faster scenario testing reduces waste in both time and cost.

Overview: Why IAS Exists

These advancements are now achievable through an **Intelligent Automation System (IAS)**—a system that goes beyond common expectations of AI. Drawing inspiration from Toyota's principle of autonomation (often described as "automation with a human touch"), IAS integrates computational power with human expertise. It strikes the right balance: computers perform large-scale calculations, simulation, and structured processing, while subject-matter experts refine assumptions, guide decisions, and validate outputs.

IAS and BIM: Completing the Original BIM Vision

An IAS provides the kind of objective knowledge resource envisioned in the original concept of Building Information Modeling. The National BIM Standard defines BIM as:

> "…a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward."

Autodesk Revit is an exemplar platform for the design-oriented portion of this definition. However, Revit does not fundamentally inform early decisions; rather, it primarily documents decisions already made through a geometric design model that is typically developed well after the inception of a space or facility need.

An IAS, by contrast, provides an objective knowledge resource from the very inception of the need, forming a reliable basis for early program, scope, design, and procurement decisions. In this way, IAS (working together with design-based modeling tools such as Revit) advances the real estate development and construction industry toward the original BIM vision: decision-grade knowledge from inception onward, not just digital documentation after decisions are locked in.

What IAS Enables in Early Planning

With IAS, owners and their advisors can, from the earliest stages, model and compare multiple space programs, evaluate site options, define building scope, generate milestone schedules, and produce reliable cost models. The required inputs are straightforward: the owner's core business case expressed as program requirements, plus key attributes associated with the owner, site, and project constraints.

IAS provides a reliable, automated alternative to conventional space programming, scope definition, and budget estimating—processes that remain largely fragmented, manual, and inconsistent across the industry.

As a result, owners can resolve a meaningful portion of uncertainty and risk before assembling the full design and construction team. Once baseline scope and budget are established, IAS equips designers, consultants, and builders with a more structured, transparent, and collaborative process for guiding the project toward optimized scope, design, and cost outcomes.

At its core, IAS applies principles from systems thinking and complexity science to form a robust "system of systems." It can process countless interdependent variables and scenarios to produce accurate predictions of outcomes. For the first time, facility planning can be treated as a measurable system of causes and effects, shifting what has historically been unpredictable and reactive into a process that is manageable, repeatable, and far more efficient.

IAS provides the supporting data structures, predictive analytics, and workflows required for rapid real-time updates as conditions evolve. These updates incorporate refined inputs, human judgment, and new information as programming, design development, and decision-making progress.

Most IAS users do not need to understand the intricate internal mechanisms of the underlying data system. These details are intentionally designed and maintained "under the hood" of the operating platform, **Building CATALYST**, in this case. This paper takes the reader beneath the philosophical and scientific hood, but avoids burdening practitioners with layers of proprietary algorithms and data tables. What matters is that the system is firmly grounded in proven systems theory and complexity science. Equally important, practitioners should feel confident validating its outputs through direct use, building trust through observable process improvements and measurable value.

A Deming-Based Systems Approach

Intelligent Automation is aligned with Toyota's autonomation principles and rooted in the systems thinking of quality and improvement pioneer W. Edwards Deming. Deming defines a system as: "A network of interdependent components working together to accomplish the aim (purpose) of the system." IAS applies this definition by modeling construction as a system of causes and effects.

- **Causes:** purpose + requirements (attributes)
- **Effects:** space program, scope parameters, schedule, and cost outcomes

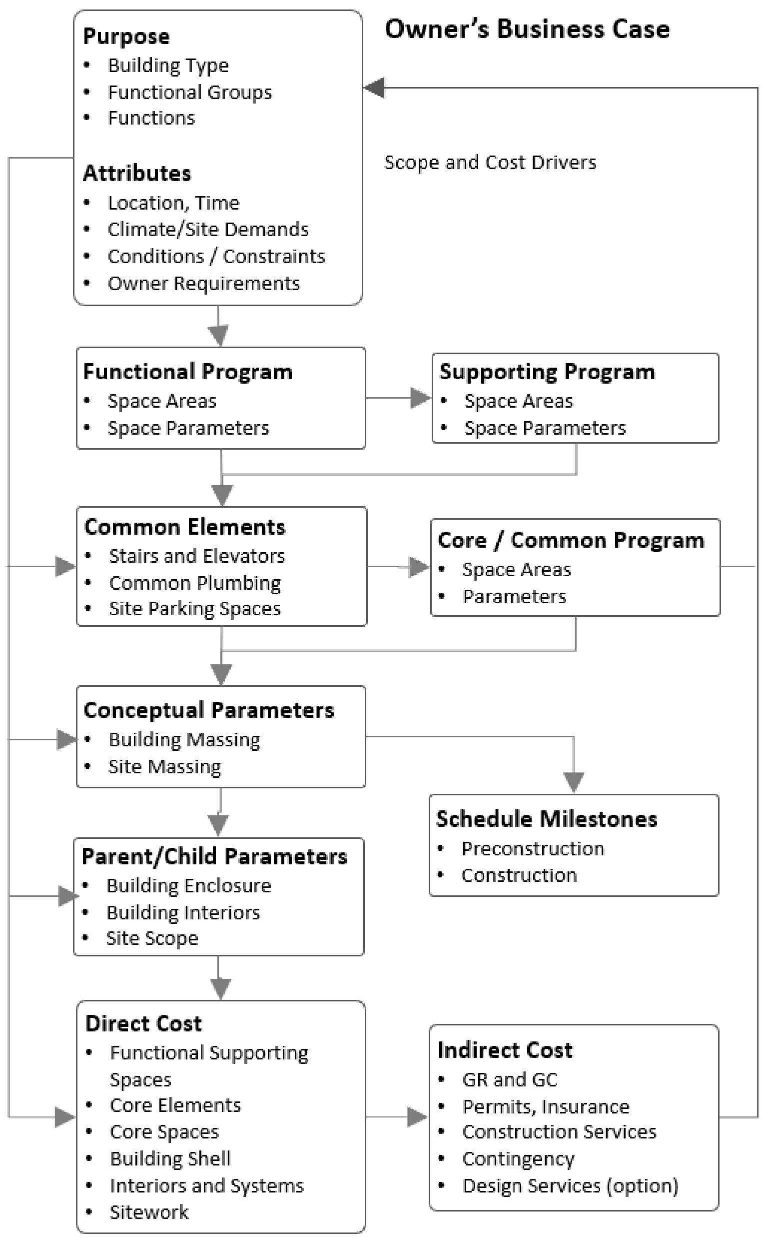

Figure 1 — Construction as a System and CATALYST Calculation Engine

Figure 1 illustrates how purpose and measurable attributes drive downstream outcomes including program, scope parameters, schedule milestones, and cost.

Ontology: Organizing the Causes into Structured Inputs

True modeling and management become possible when the essential causes are known. IAS organizes causes into an ontology (structured data hierarchy):

Purpose

- building type (e.g., Medical Center)
- functional group/department (e.g., Radiology)
- specific functions (e.g., CT Scanning)

Attributes

- demands, constraints, requirements
- examples: location, climate, quality class, and more

Nearly all of these causes can be known before the space program and design are fully developed. As a result, IAS can apply predictive modeling and analytics to estimate, within a range of variation, the following:

- space program
- site and building massing
- key design parameters
- construction cost outcomes

Objective knowledge in complex facilities can only be acquired by applying complexity science plus a disciplined scientific method.

The Scientific Method Applied (Deming-Shewhart PDSA)

The Scientific Method provides an empirical process for acquiring knowledge, characterized by careful observation and rigorous skepticism. This involves creating hypotheses through inductive reasoning, testing them through experiments (observations), and adjusting based on results. CATALYST employs the Deming-Shewhart PDSA (Plan-Do-Study-Act) cycle version of the Scientific Method, as shown in Figure 2.

Figure 2 — CATALYST Version of the Deming-Shewhart PDSA Cycle

This cycle represents how IAS continuously learns from real projects to refine predictions and reduce variation.

CATALYST has been applied to over 800 real-world projects, with roughly 150 deep analytical studies involving up to 200 data entities per project. Thousands of iterations of PDSA have demonstrated that IAS can model and inform decisions to establish program, scope, and costs across many building types.

To fully explain every algorithmic interaction would require a much longer technical volume. But IAS credibility is not ultimately proven through explanation, it is proven through outcomes.

Healthy skepticism from cost professionals is best resolved by using the PDSA cycle with real project data and validating results.

Standardization (5S) and Variation Reduction

Another important concept the applied scientific method relates to Toyota's 5S strategy. All critical data, even across highly complex buildings, can now be standardized, structured, streamlined, systematized, and stabilized as shown in Figure 3.

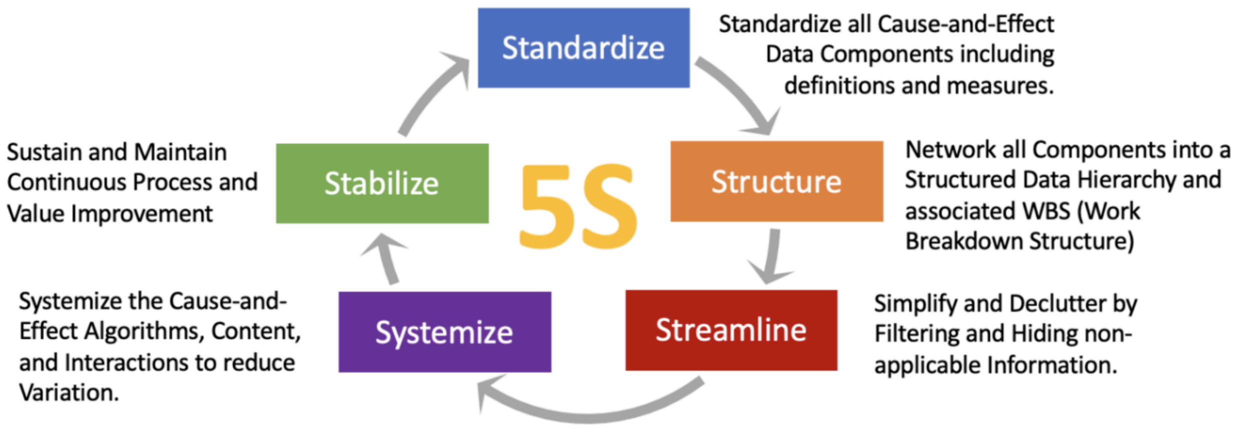

Figure 3 — The CATALYST 5S Strategy

Per Deming's system of knowledge, the objective is to reduce variation. The more project data that is submitted and analyzed, the greater the reduction in variation. IAS stabilizes outcomes first, then continuously reduces variation (waste) to optimize outcomes.

Standards: Systems-Based vs Materials-Based Thinking

Explaining all IAS modeling workflows in full depth would require an extensive guide. However, because cost modeling is a primary interest for most professionals, this paper focuses on system-based cost logic.

The CSI Masterformat structure continues to pose a major barrier to early planning because it is materials-based. Many estimating practices attempt to force-fit Masterformat into early budgets, before materials are defined.

Uniformat solves this by organizing projects by building systems, which aligns with early-stage cause-and-effect reasoning.

CATALYST contains 62 standardized building systems at Uniformat Level 2.5 (a hybrid of Levels 2 and 3), including indirect costs. Each system contains functions, attributes, and parameters, leading to thousands of possible combinations required to model costs consistently.

Worked Example 1: B201 — Exterior Wall System

Each standardized system includes explicit definitions of what is included and excluded.

B201 - Exterior Wall Systems

Includes: Exterior wall surface, back-up, lintels and ledge angles, insulation, joint sealants, waterproofing/membranes, expansion joints, inside surface (GWB including tape and finish). Steel framing for curtainwall system, non-vision (spandrel) glass and metal panel, including associated aluminum framing, as applicable. Parapets, screen walls, and wing walls. Exterior column enclosures. Exterior load bearing walls. Canopy, balcony and other exterior ceilings and soffits (note that area is included in exterior building area). Exterior walkway and patio railing. Solar screening and sun shading. Exterior louvers, screens, and grillage.

Excludes: Exterior glazing systems. Site screening walls. Walls associated with site development. Finishing inside surface of exterior walls.

Figure 4 — CATALYST System Definition and Level 1 Normalization Example

Exterior wall costs are driven primarily by building type and attributes rather than interior functions/spaces.

Attribute Factoring	
Building Height - Levels 12 to 15	1.15
Seismic Design Category - SDC A	1.05
Climate Zone - CZ4a (Mixed-Humid)	1
Location Type - Dense Urban	1.1
Quality Class - Standard (Commercial) Grade	1
Development Stage - Early Planning	0.95
Gross Building Area - > 160K GSF	0.95
Energy/Environment - LEED Certified	1.05
Construction Start - Sept, 2025 (from Jan, 2020)	1.49
State Region: Greater St. Louis, MO	1
Total Factor (No Interactions)	1.9
Total Factor (With Interactions)	1.8

Figure 5 — CATALYST Attribute Factoring Applied to Exterior Walls

Attributes such as Seismic Design Category can strongly impact exterior walls but may have little effect on other systems (e.g., floor finishes).

Based on the IAS calculation sequence, CATALYST predicts building massing from the total program and key attributes. For the building shell it predicts:

- total wall area above and below grade
- percent glazing in above-grade walls
- breakdown of B20 Vertical Exterior Enclosure into subcategories (walls/windows/doors)

For the B201 – Exterior Wall System, CATALYST predicts the quantities of specific parameters to create the most accurate cost model. Figure 6 demonstrates this regarding the mean cost while also calculating the statistical low and high range values.

B20 - Vertical Exterior Enclosure	QTY	UoM	Unit Cost	Total Cost
B201. Exterior Wall Systems	76,289 SF	SF	$92.57	$7,062,342
B202. Exterior Windows	50,859 SF	SF	$129.46	$6,584,459
B203. Exterior Doors	34 EA	EA	$6,290.61	$213,881
	127,148 SF	SF	**$109.01**	**$13,860,682**

B20 - Vertical Exterior Enclosure	QTY	UoM	Unit Cost	Total Cost
B201 - Exterior Wall Systems	**76,289**	**SF**	**$92.57**	**$7,062,342**
Exterior Insulated/Opaque Wall	72,398	SF	$90.94	$6,583,952
Exterior Non-enclosure Wall	3,891	SF	$52.30	$203,496
Exterior Railing	182	LF	$142.64	$25,960
Solar Screening	610	SF	$71.32	$43,503
Exterior Ceilings & Soffits	2,233	SF	$28.53	$63,700
Balcony / Plaza	3,220	SF	$44.02	$141,731

Figure 6 — Exterior Wall: Parameters-Driven, Attribute-Factored Cost Model

This figure demonstrates how attribute factoring influences baseline outcomes and how system parameters drive accuracy.

Worked Example 2: D300 — HVAC Generating System

CATALYST's mathematical approach adapts uniquely to each building system. The HVAC scope provides an example of how CATALYST focuses on causal factors rather than materials. The principal causes influencing HVAC costs include the function of the building (the owner's business case or occupancy purposes) and key attributes (such as location, climate, construction type, quality class, HVAC approach, and more).

In Figure 7, we see how multiple layers of causes are necessary to accurately model HVAC costs. First, it's important to separate the Generating and Distribution systems. The climate (external heating and cooling demand/load) has a greater impact on the generating system, whereas the varying occupancies (internal cooling demand/load) influence the distribution system more. The variations become the most significant when shell, in-building parking, and other low intensity spaces are included.

D30. HVAC	QTY	UoM	Unit Cost	Total Cost
D300. HVAC Generating Systems	411,454	GSF	$7.30	$3,002,576
D304. HVAC Distribution Systems	411,454	GSF	$4.53	$1,865,718
D308. Controls and Instrumentation	411,454	GSF	$1.18	$484,163
	411,454	GSF	$13.01	**$5,352,457**

D30. HVAC	QTY	UoM	Unit Cost	Total Cost
D300. HVAC Generating Systems	**411,454**	**GSF**	**$10.79**	**$3,002,576**
Building Shell	411,454	GSF	$2.10	$865,923
Core and Common	86,904	SF	$3.39	$294,752
Supporting Program	13,877	DGSF	$17.89	$248,206
Condominiums	109,945	DGSF	$5.90	$648,419
Hotel	38,360	DGSF	$7.74	$296,976
Bar and Restaurant	5,169	DGSF	$7.99	$41,280
Banquet / Conference	18,146	DGSF	$5.56	$100,957
Office Shell	50,000	DGSF	$6.03	$301,520
Retail Shell	20,000	DGSF	$6.03	$120,608
Amenities	3,149	DGSF	$18.77	$59,091
Parking	69,125	DGSF	$0.36	$24,844

D30. HVAC	QTY	UoM	Unit Cost	Total Cost
Building Shell	**411,454**	**GSF**	**$2.10**	**$865,923**
Total Roof Area	27,934	SF	$4.42	$123,399
Exterior Insulated/Opaque Wall	72,398	SF	$2.91	$210,408
Exterior Building Glazing	50,859	SF	$10.46	$532,116

Figure 7 — HVAC Demands-Driven, Attribute-Factored Cost Model

This figure shows how multiple layers of causes are needed to predict HVAC scope accurately.

As this figure shows, external factors like the climate's load on glazing can create some of the highest demands for heating and cooling generation. However, in intensely occupied facilities, such as medical or science and research centers, the impact of climate load on generating systems is far less significant compared to the high internal cooling and ventilation demands from occupancy.

In this example, there's a dramatic variation in occupancy demands from parking (minimal) ($0.36/sf) to the supporting spaces ($17.89/sf) that includes the high intensity commercial kitchen.

The level of detail involved in a single Uniformat Level 2.5 cost code, like HVAC Generation System, is substantial, far beyond what any human could reasonably track manually.

You should also note that the type of inputs that CATALYST accounts for in modeling the first cost, are the same that will be needed to model the life cycle energy and other facility operational costs. Life cycle analysis and total cost of ownership are part of a holistic IAS vision.

IAS as a Function-Based “System of Systems”

Again, complex buildings can now be standardized, structured, streamlined, and stabilized within a consistent planning and cost modeling system. Rather than wading through thousands of non-contextualized estimate line items (often 1,000+), owners and their advisors can see the entire project picture at once — and then dynamically drill down to identify, analyze, and resolve risks (or capture opportunities).

CATALYST accomplishes this by aggregating potentially dozens of detailed micro-cost models into a single coherent structure. Figures 8A–8C illustrate three examples, starting at a high summary level.

Program Group	QTY	Unit Cost	Total Cost
Sitework	**411,454 GSF**	**$7.94**	**$3,265,129**
Building Shell	**411,454 GSF**	**$119.98**	**$49,367,855**
Functional Spaces	310,674 DSF	$96.68	$30,035,813
Condominiums	107,525 DSF	$141.32	$15,195,036
Hotel	37,560 DSF	$188.94	$7,096,515
Bar and Restaurant	5,169 DSF	$152.74	$789,489
Banquet / Conference	18,146 DSF	$109.20	$1,981,594
Office Shell	50,000 DSF	$36.58	$1,828,942
Retail Shell	20,000 DSF	$36.58	$731,577
Amenities	3,149 DSF	$281.86	$887,443
Parking	69,125 DSF	$22.06	$1,525,217
Supporting Spaces	13,877 SF	$231.99	$3,219,392
Core & Common Spaces	90,583 SF	$171.98	$15,578,648
Indirect Services	411,454 GSF	$60.28	$24,801,742
Construction Total	**411,454 SF**	**$306.88**	**$126,268,578**

Supporting Spaces	13,877 SF	$231.99	$3,219,392
Public / Administrative	5,411 SF	$145.71	$788,428
Building Services (BOH)	6,232 SF	$132.55	$826,032
Kitchen	2,234 SF	$718.36	$1,604,932

Figure 8A — Cost Model Summary by Category

Figure 8A summarizes the project cost model across key categories: Sitework, Building Shell, and three program space types — Functional (directly tied to the owner’s business case), Supporting (back-of-house and support spaces such as the commercial kitchen), and Core & Common areas. The figure also drills into the supporting spaces and reveals how dramatically interior costs can vary — from **Parking ($22.06/SF)** to **Kitchen ($718.36/SF)**. Behind these high-level cost-per-square-foot summaries is a detailed, data-backed micro-cost model (shown at approximately Uniformat Level 2.5), similar to what is shown in **Figure 9C.**

This is the practical advantage owners gain during early planning and feasibility: confidence that the program and cost models are grounded in real calculations and real-world data, not generalized assumptions.

Just as importantly, rapid navigation from summary to detail is now possible. In as few as three clicks, a user can move from total building cost → to the program summary → to supporting space summaries → to the underlying functional micro-cost models.

Figure 8B illustrates this same drill-down capability using a **Condominium micro-cost model.**

Program Group	QTY	Unit Cost	Total Cost
Sitework	**411,454 GSF**	**$7.94**	**$3,265,129**
Building Shell	**411,454 GSF**	**$119.98**	**$49,367,855**
Functional Spaces	310,674 DSF	$96.68	$30,035,813
Condominiums	107,525 DSF	$141.32	$15,195,036
Hotel	37,560 DSF	$188.94	$7,096,515
Bar and Restaurant	5,169 DSF	$152.74	$789,489
Banquet / Conference	18,[illegible]		
Office Shell	50,[illegible]		
Retail Shell	20,[illegible]		
Amenities	3,1[illegible]		
Parking	69,[illegible]		
Supporting Spaces	13,[illegible]		
Core & Common Spaces	90,[illegible]		
Indirect Services	411[illegible]		
Construction Total	411[illegible]		

Condominiums

C - Interiors	**107,525**	**SF**	**$57.30**	**$6,160,702**
C10 - Interior Construction	107,525	SF	$42.52	$4,572,318
C101 - Partitions	22,170	LF	$95.65	$2,120,572
C103 - Interior Doors	1,475	EA	$1,317.84	$1,943,421
C109 - Interior Specialties	109,945	SF	$4.62	$508,325
C20 - Interior Finishes	107,525	SF	$14.77	$1,588,384
C201 - Wall Finishes	109,945	SF	$5.81	$639,180
C203 - Floor Finishes	109,945	SF	$6.35	$698,571
C205 - Ceiling Finishes	109,945	SF	$2.28	$250,632
D503 - Electrical Branch Power	109,945	SF	$7.38	$810,905
D504 - Building Lighting	109,945	SF	$2.86	$314,116
D70 - Safety Systems	107,525	SF	$2.75	$296,216
D705 - Fire Alarm	109,945	SF	$2.69	$296,216
E - Fixed FF & E	**107,525**	**SF**	**$24.49**	**$2,633,151**
E10 - Fixed Equipment and Furnishings	107,525	SF	$15.68	$1,686,254
E100 - Fixed F F and E	109,945	SF	$15.34	$1,686,254
E20 - Furnishings	107,525	SF	$8.81	$946,897
E200 - Furnishings and Appliances	109,945	SF	$8.61	$946,897
Total	**107,525**	**SF**	**$141.32**	**$15,195,036**

Figure 8B — Condominium Micro Cost-Model Example

Referring back to **Figure 1** (CATALYST Calculation Engine), the Supporting Spaces are derived directly from the Functional Spaces. The Core & Common spaces are then derived from the combined total of Functional and Supporting spaces, together with key building attributes such as the number of levels, HVAC approach, and other major configuration drivers.

Once the interior program is established (Functional + Supporting + Core/Common), CATALYST derives the building's massing and site parking requirements. These outputs then enable the Sitework and Building Shell micro-cost models to be composed. **Figure 8C** illustrates this same process for the Building Shell.

Program Group	QTY	Unit Cost	Total Cost
Sitework	**411,454 GSF**	**$7.94**	**$3,265,129**
Building Shell	**411,454 GSF**	**$119.98**	**$49,367,855**
Functional Spaces	**310,674 DSF**	**$96.68**	**$30,035,813**
Condominiums	107,525 DSF	$141.32	$15,195,036
Hotel	37,560 DSF	$188.94	$7,096,515
Bar and Restaurant	5,169 DSF	$152.74	$789,489
Banquet / Conference			
Office Shell			
Retail Shell			
Amenities			
Parking			
Supporting Spaces			
Core & Common Spaces			
Indirect Services			
Construction Total			

Building Shell			
A - Substructure	**411,454 GSF**	**$12.58**	**$5,175,112**
A10 - Foundations	411,454 GSF	$7.28	$2,993,482
A101 - Foundations	27,458 SF	$109.02	$2,993,482
A20 - Basement Construction	411,454 GSF	$3.64	$1,496,568
A201 - Basement Wall System	21,700 SF	$68.97	$1,496,568
A40 - Grade Slab	411,454 GSF	$0.67	$274,685
A401 - Slab on Grade	27,458 SF	$10.00	$274,685
A90 - Substructure Support	411,454 GSF	$1.00	$410,378
A901 - Substructure Earthwork	27,458 SF	$14.95	$410,378
B - Shell	**411,454 GSF**	**$79.25**	**$32,606,487**
B10 - Superstructure	411,454 GSF	$44.68	$18,382,258
B101 - Floor Construction	383,997 SF	$45.03	$17,289,874
B102 - Roof Construction	27,934 SF	$39.11	$1,092,384
B20 - Vertical Exterior Enclosure	411,454 GSF	$33.36	$13,726,606
B201 - Exterior Wall Systems	76,289 SF	$90.82	$6,928,266
B202 - Exterior Windows	50,859 SF	$129.46	$6,584,459
B203 - Exterior Doors	34 EA	$6,290.61	$213,881
D50 - Electrical	411,454 GSF	$2.79	$1,146,279
D501 - Power Generation	411,454 SF	$2.39	$981,840
D502 - Electrical Service and Feeder	411,454 SF	$0.40	$164,439
Total	**411,454 SF**	**$119.98**	**$49,367,855**

Figure 8C — Building Shell Micro Cost-Model Example

Geo-location and Escalation

Establishing a reliable basis for detailed program definition, parameters (quantities), and cost models requires a PDSA cycle, including testing, calibration, and refinement using real-world microeconomic data. There is no other reliable way to process the thousands of interacting cause-and-effect combinations that drive building cost outcomes. Without structured calibration to real data, the only alternatives are intuition and subjective judgment, approaches that lack both objectivity and repeatability.

Fortunately, credible macroeconomic data resources exist that allow costs to be normalized across both space (location) and time (escalation). *RSMeans*, for example, publishes a City Cost Index (CCI) for more than 600 U.S. cities, providing a defensible method for adjusting costs from one region to another.

Likewise, resources such as *Construction Analytics* enable long-term tracking of construction escalation relative to national inflation, including associated trends in material and wage rate increases since 1967, as shown in Figure 9.

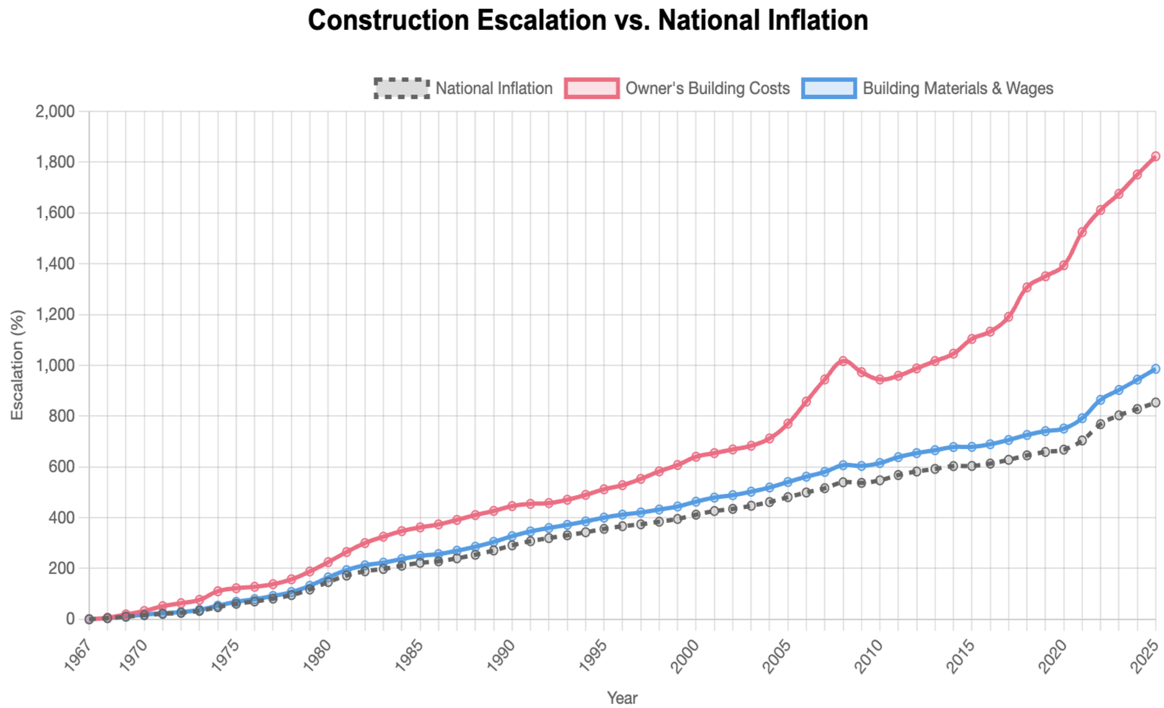

Figure 9 – CATALYST: Construction Escalation vs. National Inflation

As shown, construction escalation has increased total building costs to roughly 2.1× what owners would pay if costs had tracked national inflation alone. Modest divergence in the early decades gave way to sharper surges beginning around 2004, again around 2018, and most dramatically during the COVID-19 era. While material pricing has stabilized relative to peak volatility, many owners remain more exposed than ever, driven by uncertainty, shortened decision windows, and in some cases, opportunistic pricing behavior.

As a result, construction remains in a highly volatile, inflationary environment, making it increasingly difficult for estimators and cost professionals to produce budgets that are both accurate and reliable early in planning.

Statistical Modeling and Variability in Cost Predictions

CATALYST's approach incorporates statistical modeling based on the successive estimating method developed by Danish construction cost expert Steen Lichtenberg. This method explicitly accounts for the fact that some building systems exhibit substantially higher variability than others. For example, Sitework and Exterior Enclosure typically show much greater statistical spread than many interior construction elements. Importantly, this variability often persists even after major driving causes, program functions and key attributes, have been accounted for.

To achieve the most accurate results with minimal effort, CATALYST encourages a shift from broad, inductive approximations to deductive, system-specific estimating. **Figure 10** illustrates this principle through the wide variation present in the market baseline prediction for the Vertical Exterior Enclosure. By drilling down into distinct enclosure strategies, the primary sources of variation can be isolated and resolved early, even during conceptual design.

The baseline highlights meaningful differences between enclosure approaches such as Masonry/EIFS, Architectural Precast + Curtainwall, and Curtainwall + Structural Glass. Once these alternatives are separated and evaluated individually, uncertainty can be reduced through targeted research, precedent benchmarking, and focused scope definition, allowing teams to move from probabilistic ranges toward decision-grade cost certainty much earlier in the process.

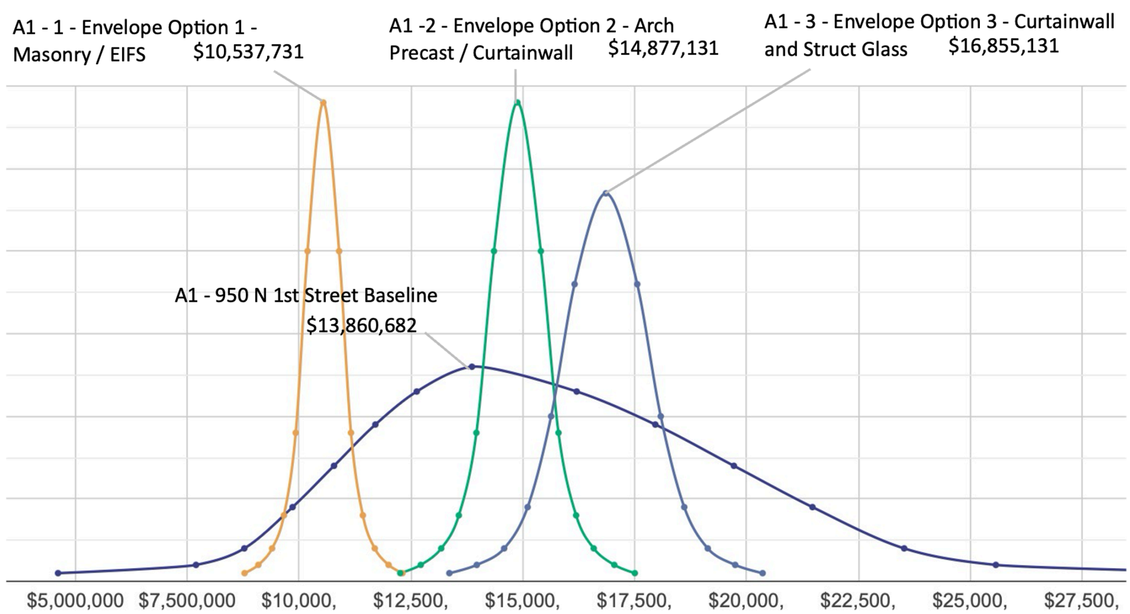

Figure 10 — Vertical Exterior Enclosure Options Study (Variation Range)

These optional studies can be completed either within CATALYST or using third-party estimating tools (including Excel). If performed externally, results can be imported back into CATALYST, allowing it to function as the central cost management hub for end-to-end tracking and ensuring the project remains aligned with its target value and budget.

The Deming Goal: Resolving Variation (Five Stages)

Resolving excessive variation (i.e., uncertainty and waste) from the earliest planning stages through schematic design progresses through five stages, as shown in **Figure 11**.

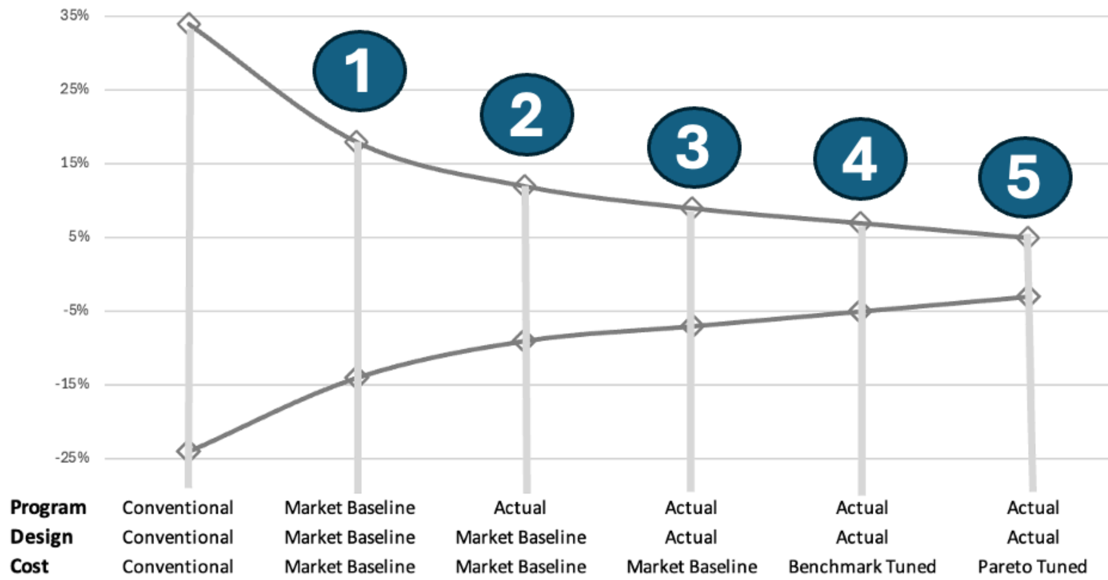

Figure 11 – CATALYST: Variation Reduction Progression

As noted earlier, Intelligent Automation reflects Toyota's concept of autonomation ("automation with a human touch") by striking the optimal balance between computational processing (technology + structured data) and human expertise. Across all five stages, subject-matter experts apply judgment and project-specific knowledge to refine, validate, and tune the data-driven predictive models.

STAGE 1 – Early Planning / Feasibility

CATALYST resolves a substantial portion of potential variation before a space program is established, using broad market baseline predictions (average and range) for:

- space program assumptions,
- scope and design parameters, and
- overall building cost.

STAGE 2 – Space Programming

Once the space program is approved, it is imported into CATALYST along with site parking requirements and key site/building attributes. This enables Stage 2 reduction in variation through calibrated market baseline predictions for:

- site requirements and massing implications, and
- construction costs tied to the programmed scope.

STAGE 3 – Conceptual Design

As conceptual design develops, the actual site and building configuration, including massing parameters and control quantities, are imported into CATALYST. This produces Stage 3 reduction in variation by anchoring cost prediction to:

- the project's real geometry and governing quantities, and
- refined market baseline system costs.

STAGE 4 – Benchmark Tuning

Multiple models are generated to compare the broad (unknown-project) market baseline against known benchmark projects, based on owner/team experience and real-world reference data. This benchmarking process supports schematic design decision-making and enables Stage 4 reduction in variation by:

- evaluating efficiency and cost competitiveness, and
- tuning assumptions toward credible, experience-based targets.

STAGE 5 – Schematic Design + Pareto Tuning

CATALYST's Pareto Variation Analysis identifies the building systems with the greatest variability, where the highest risks, threats, and opportunities reside. This allows the team to focus effort where it matters most while transitioning from systems-based modeling toward targeted assembly- and material-level research and estimating. The result is Stage 5 reduction in variation through:

- prioritization of high-impact systems, and
- focused validation and refinement of cost drivers.

While this progression may appear to add work, the opposite is true. Most of the data standards, structures, and processing are built in advance. As teams become proficient in operating the IAS, CATALYST in this case, much of the conventional manual effort is removed. This shifts time away from tedious estimate assembly and toward higher-value work: problem solving, risk resolution, and measurable improvement.

AI-Driven Data Mapping and Translation

IAS and AI risk being conflated, but they serve fundamentally different roles. IAS is a testable, systems-based model of causes and effects that produces objective predictions through standardized structure and PDSA calibration. AI does not replace this logic, instead, it serves as a workflow acceleration layer that reduces friction in data translation and learning.

The primary bottleneck in cost modeling is not computation, but translation: valuable historical cost knowledge is often trapped in inconsistent naming conventions, legacy coding structures, PDFs, and non-standard formats. AI helps remove this bottleneck by accelerating:

- translating historical cost data into standardized codes (e.g., Masterformat, G703 → Uniformat systems)
- mapping inconsistent naming conventions into structured system definitions
- accelerating data ingestion to increase the throughput of PDSA learning cycles
- improving consistency in classification and observation tracking

As AI improves, it will expand the speed and breadth of IAS learning by enabling:

- larger project datasets to be standardized quickly
- faster calibration cycles
- richer attribute extraction (scope, quality, climate, configuration)
- broader interoperability across naming systems and legacy data formats

However, IAS remains grounded in objective, measurable cause-and-effect structure and can be validated using real project outcomes. The future is not "AI that estimates," but IAS + AI, where IAS provides decision-grade structure and scientific credibility, and AI expands learning throughput, improves usability, and strengthens the workflow that makes continuous improvement possible.

Together, they move facility planning and cost management toward the original aim: earlier certainty, less waste, and better outcomes.

Conclusion: The Proof is in the Pudding

The value of IAS is best judged by outcomes. IAS represents a shift away from fragmented, manual workflows and toward an operating system that is:

- structured
- testable
- improvable
- repeatable
- anchored in real-world project data

To learn more about IAS and see it in action, visit:
www.buildingcatalyst.com

A Note to Innovators and Leaders Who Want to Learn More

Construction needs a new generation of innovators and leaders—people willing to replace today's fragmented practices with a full-fledged ***operating system*** *for facility planning, design, and cost management. The technical obstacles are not the limiting factor. The real challenge is* *building capability and changing incentives: training teams to operate data-driven systems, and rewiring contracting structures to reward measurable improvement.*

These two articles further develop that vision:

- ***The Power of Intelligent Automation to Reinvent Construction***
- ***An Academia / Industry Collaborative to Reinvent Construction***

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