INCOSE Michigan Chapter

Monthly Newsletter

June 2026

In This Issue

President's Message

I would like to thank Dr. Douglas Neeley for his leadership in 2025; we just learned that INCOSE Michigan received a 2025 Silver Chapter Circle Award.

May was a whirlwind for me; I started off the month in Las Vegas on vacation with my wife, then went to the CATIA User Symposium Americas (CUSA) in Reno, and then traveled to the Mars Society's University Rover Challenge (URC), held at the Mars Desert Research Station in Hanksville, Utah. In addition to seeing Piff the Magic Dragon, Penn and Teller, the Sphere, O, Mystere, and the taping of a new BattleBots episode (the quarter finals, which included two of my favorite bots!), I visited Battlefield Vegas. This venue provides access to a colossal selection of vintage and modern firearms. I was able to enjoy a once-in-a-lifetime experience and shot some amazing WWII vintage weapons as well as a .50 Barrett sniper rifle. I was struck by the differences in how these weapons, all contemporaries (except for the .50), were designed. The systems engineering and requirements for each drove vastly different shooting experiences…from the suppressed M3 (my favorite) to the Browning Automatic Rifle and MG42. This has inspired me to focus this month's Historical Corner on these weapons.

I had the honor of judging teams at the URC for the first-ever INCOSE Foundation Systems Engineering Excellence Award. I will share more about this experience in an upcoming newsletter.

On June 5, I will be presenting at the System-as-Code-Fest 2026 (hosted by Sensmetry and System Strategy) and then hosting our SysML v2 Vendor Showcase on the 6th (immediately followed by our inaugural System Soirée at the Inn at St. John's). Registration for these events is still open!

I will not attend the Packards and Pours Event at the Packard Proving Grounds but am looking forward to seeing Jeremy Ross, INCOSE Michigan member (Ford Motor Company/University of Detroit Mercy) and our May presenter, receive the Engineering Society of Detroit Young Engineer of the Year Award on June 23rd.

On June 24th, Ziggy Gelbuda from Sensmetry will present *Systems Integrated Digital Engineering with SysML v2 in the AI Age*, giving us another look at emerging SysML v2 tools.

I hope to see you at one of our events!

Michael J. Vinarcik, ESEP-Acq, P.E, FESD

President

Chapter News

Jeremy Ross, CSEP, is the 2026 Engineering Society of Detroit Young Engineer of the Year (honoring engineers under the age of 35 for outstanding contributions to the engineering community).

Upcoming Events Calendar

Date	Event	Organization
June 5	System-as-Code-Fest	Sensmetry/System Strategy, Inc.
June 6	SysML 2.0 Vendor Showcase	INCOSE Michigan Chapter
June 6	Systems Soirée: Inaugural Dinner	INCOSE Michigan Chapter
June 13	Packards & Pours	Packard Proving Grounds
June 18	AI-Powered Happy Hour	PMI Great Lakes Chapter
June 23	ESD Annual Dinner	Engineering Society of Detroit
June 24	Systems Integrated Digital Engineering with SysML v2 in the AI Age	INCOSE Michigan Chapter
June 24	Beyond the Black Box - Understanding and Interpreting Generative AI Output for Project Management	PMI Great Lakes Chapter
July 16	AI at the Crossroads of Economics, Patient Outcomes, and Value	INCOSE Chicagoland

Upcoming Chapter Events

SysML v2 Vendor Showcase

Date: June 6, 2026

Location: The Engineering Society of Detroit, 20700 Civic Center Drive, Suite 450, Southfield, MI 48076

SysML v2 tool vendors will converge on the Engineering Society of Detroit on June 6 for a full-day showcase that goes well beyond the usual vendor demo day. Each vendor was given one of two Michigan-relevant automotive engineering challenges — an EV Battery Management System or a Power Window Controller with anti-pinch safety compliance — and has been building a complete SysML v2 model over the past two months. On event day, they will walk through their models, demonstrate their tools side-by-side, and then do something that has rarely been attempted at this scale: import each other's models and show what survives the round-trip.

Confirmed Vendors:

- Celedon Systems
- Dassault Systèmes
- Mgnite, Inc.
- Sensmetry/SysIDE
- Sysmodeler

What to Expect

Morning sessions feature 35–40 minute vendor demonstrations, each using their challenge model to walk through requirements, structure, behavior, parametrics, and tool-specific differentiators. The BMS scenario covers battery thermal management, CAN bus interfaces, and state-of-charge estimation. The Power Window Controller scenario involves FMVSS 118 anti-pinch regulatory compliance, motor force

modeling, and safety-critical state machines — and is particularly well-suited for vendors wanting to demonstrate simulation or CAD integration capabilities.

The afternoon interoperability showcase is where this event stands apart. Prior to the event, vendors will have exchanged models through a shared repository and attempted cross-tool imports. During the afternoon session, they will present these results using a common scorecard: what elements transferred successfully, what required manual adjustment, and what was lost in translation. This is a collaborative exercise — the goal is to give the community an honest, structured picture of where SysML v2 interoperability stands today.

Why Attend

If you are evaluating SysML v2 tools, planning an MBSE transition, or simply want to understand where the new standard stands, this event will deliver more actionable information in one day than months of vendor webinars. You will see the same engineering problems modeled in five competing tools, with real interoperability data — not marketing slides.

For those who attended our sold-out SysML v2 3-Day Bootcamp with Dassault Systèmes in April, this is the natural next step: apply what you learned to critically evaluate the tools available to you.

Virtual Attendance and Watch Parties

Can't make it to Southfield? A livestream will be available to registered attendees. We are also coordinating watch parties with other INCOSE chapters — if your chapter is interested in hosting one, please contact us at michael.vinarcik@incose.net.

Register: https://lp.constantcontactpages.com/ev/reg/uksxc9u

Systems Soirées: Inaugural Dinner

Date: Saturday, June 6, 2026
Time: 5:00 – 7:00 p.m.
Location: The Inn at St. John's, 44045 Five Mile Road, Plymouth, MI 48170

Cap off a full day of SysML v2 demonstrations with the first-ever INCOSE Michigan Systems Soirée. After watching five tool vendors tackle the same engineering challenges, join fellow attendees and several of the participating vendors for dinner at the Inn at St. John's.

The Vendor Showcase delivers the data; the Systems Soirée delivers the conversation. This is your chance to dig deeper with vendors and peers in a relaxed setting.

Seating is limited to 12, so this intimate gathering will fill quickly. Reserve your ticket early to guarantee your seat at the table.

Cost: $25

Register at https://lp.constantcontactpages.com/ev/reg/eary68b

Sidequest Social: Packards & Pours

Date: Saturday, June 13, 2026
Time: 6:00 – 10:00 p.m.
Location: Packard Proving Grounds Historic Site, 49965 Van Dyke Avenue, Shelby Township, MI 48317

Craft beer, wine, cocktails — and classic cars under the evening sky at one of Michigan's most atmospheric automotive heritage sites. Packards & Pours is the Packard Motor Car Foundation's signature summer fundraiser (formerly Packards & Pints), set among the original 1928 Tudor Revival buildings where Packard engineers once tested luxury automobiles on a 2.5-mile oval track.

Tour the historic Lodge, Repair Garage, and WWII Tank Test Center while enjoying drinks, food, and live music. All proceeds support the continued restoration of this 17-acre landmark. This is a relaxed, social evening — an ideal opportunity for chapter members and guests to mingle in a setting that practically defines Michigan automotive heritage.

Cost: $50

Register at https://packardprovinggrounds.org/event/packards-pours/

Systems Integrated Digital Engineering with SysML v2 in the AI Age

Date: June 24, 2026
Time: 12:00 PM – 1:30 PM
Location: Virtual

Join us on June 24 for a practical look at what happens when your system model becomes text you can review, diff, and automate in CI/CD. Ziggy Gelbuda from Sensmetry will walk through the SysML v2 textual representation, the SysIDE tool suite for Systems as Code, and a real satellite project case study showing the model driving generated diagnostics software, a monitoring portal, and a telemetry pipeline. He'll also cover where AI assistants fit in this workflow and how to get started—from free tools and lessons to enterprise migration.

Registration: https://lp.constantcontactpages.com/ev/reg/m8xjyru

Partner Organization Events

The Engineering Society of Detroit

ESD Annual Dinner

Date: Tuesday, June 23, 2026, 5:30 PM – 8:30 PM
Location: Vibe Credit Union Showplace, Novi, Michigan

ESD’s flagship recognition event and one of the strongest local engineering-community networking opportunities of the year. The 2026 dinner honors Frank Venegas, Jr. with the Horace H. Rackham Humanitarian Award and presents the ESD Construction & Design Awards. Jeremy Ross of Ford Motor Company and the University of Detroit Mercy — this year’s ESD Young Engineer of the Year — will receive his award at the dinner. A strong evening for members looking to connect across Southeast Michigan’s engineering leadership.

Register: https://www.esd.org/programs/annual-dinner/

PMI Great Lakes Chapter

AI-Powered Happy Hour

Date: Thursday, June 18, 2026, 6:00 PM – 8:30 PM
Location: Mother Handsome**,** 14661 W 11 Mile Rd. Suite 500, Oak Park, Michigan, 48237

Sharpen your AI fluency in a relaxed, hands-on setting. This interactive evening rotates members through practical AI-tool stations tied to real project-management work — no lectures, just facilitated conversation and strong networking. A useful, low-pressure way to see how peers are applying AI to delivery and lifecycle work. Pizza and non-alcoholic beverages provided; space capped at 45.

Cost: $15

Register: https://pmiglc.org/calendar?eventId=44982

Lunch & Learn (Virtual): Beyond the Black Box — Understanding and Interpreting Generative AI Output

Date: June 24, 2026, 12:00–1:00 PM
Location: Virtual

A practical lunch-hour session on how to interpret generative-AI output and lead teams through it with transparency, rather than treating the model as a black box. Presented by Roy Schilling, an Agile coach and trainer with 30+ years spanning strategic planning, project and product management, and systems engineering strategies — a background that lands well with an SE audience. Earns 1.0 PDU. Online registration closes at noon the Tuesday before the event.

Cost: $20 non-members

Register: https://pmiglc.org/calendar?eventId=44983

Other INCOSE Chapter Events

INCOSE Chicagoland Chapter: AI at the Crossroads of Economics, Patient Outcomes, and Value

Date: July 16, 2026, 7:00–9:15 PM EDT

Format: Virtual

An evidence-driven look at where AI in medicine actually delivers value versus where it has stalled — separating hype from real productivity measured in patient outcomes. The talk spans care quality, patient safety, real-world evidence in drug development, proteomics, quantum computing, the economics of AI, and digital twins. Presented by Dr. Jacob Krive, Clinical Associate Professor of Biomedical Informatics at the University of Illinois at Chicago, with 30+ years leading IT teams at Endeavor Health, Advocate Health, and IBM. Relevant for systems engineers working in complex, high-stakes domains where value, outcomes, and cost must be balanced. Offered via Zoom (networking 7:00, announcements 7:30, presentation and Q&A 8:00–9:15).

Register: https://www.incosechicagoland.com/events

Other Events

System-as-Code-Fest 2026

Date: Friday, June 5, 2026, 10:00 AM – 12:45 PM EDT
Format: Hybrid — in-person in Detroit, MI, or virtual via Zoom
Cost: Free

Sensmetry and Detroit-based System Strategy, Inc. are co-hosting the 2026 System-as-Code-Fest, a half-day mini-conference focused on SysML v2 and the System-as-Code paradigm. The morning session features presentations from 10 SE practitioners and thought leaders on how they are applying SysML v2 today, including in AI-enabled workflows. Following last year's event — which drew over 300 registrants and nearly 2,000 YouTube views — this year's edition brings the conference to our own backyard. On-site attendees can also join an afternoon hands-on SysML v2 training session led by Sensmetry's Kestutis Jankevicius.

Register: https://sensmetry.com/system-as-code-fest/

Greenfield Village: Salute to America

Dates: July 2-5, 2026

The iconic annual Independence Day celebration by the Detroit Symphony Orchestra and Greenfield Village, focused on America's 250th anniversary.

Registration: https://www.thehenryford.org/visit/things-to-do/calendar/salute-to-america

The Henry Ford Museum of American Innovation: Freedom Plane

Dates: July 9-26, 2026

Traveling for the first time together in history, see documents like George Washington's, Alexander Hamilton's and Aaron Burr's Oaths of Allegiance (1778); the Treaty of Paris (1783); Senate Markup of the Bill of Rights (1789); and more. The Henry Ford is one of eight institutions across the U.S. where nine original founding-era documents will be on display to the public as part of The National Archives and Records Administration traveling exhibition, Freedom Plane National Tour: Documents That Forged a Nation.

Information: https://www.thehenryford.org/visit/things-to-do/calendar/freedom-plane-national-tour

Historical Corner

One Battlefield, Eight Designs — Reading the Requirements Behind WWII Small Arms

June 2026 — 82 Years Since the Normandy Landings

By June 1944 the small arms carried into the European theater represented two decades of divergent requirements thinking compressed onto a single battlefield. On a recent trip to Battlefield Las Vegas I had the opportunity to fire eight of them — the Steyr-Solothurn MP34, the MP40, the Thompson M1A1, a suppressed M3, the M2 Carbine, the Gewehr 43, the BAR, and the MG42 — along with a modern Barrett .50 as a bonus. What struck me was not how different they feel to shoot, but how legibly each one encodes the requirements, doctrine, and production economics of the organization that fielded it. For a systems engineer, a rack of period weapons is a rack of requirements baselines made visible.

Two more sat on the rack that I never got to fire — an FG42 and an StG44, both down for want of parts — and I will return to them, because each embodies an idea the rest of the bench only circles.

One Requirement, Four Answers: The Submachine Guns

The MP34, MP40, Thompson M1A1, and M3 all satisfy essentially the same top-level requirement: deliver controllable, fully automatic fire from a handgun cartridge at close range — for trench and urban fighting, vehicle and tank crews, and paratroops. That single decision, the pistol cartridge, is the dominant architectural driver. Because a pistol round generates relatively low chamber pressure, none of these weapons needs a locked breech; a simple blowback action firing from an open bolt suffices, in which the inertia of a heavy bolt, backed by its recoil spring, holds the breech closed long enough for pressure to fall. The MP40 is a straight-blowback, open-bolt design firing 9×19mm at roughly 500 to 550 rounds per minute, and the others are variations on the same theme. Get the cartridge right and most of the architecture follows.

Where the four diverge is in the cost and manufacturability requirements layered on top. The MP34 is the prewar answer: beautifully machined, side-feeding, finely finished, and expensive — easily the most handsome weapon on the bench, and a reminder that it was built before producibility became a survival constraint. The Thompson M1A1 is a transitional one — already simplified from the earlier M1928 by dropping the Blish delayed-blowback lock for straight blowback and deleting the Cutts compensator and finned barrel, yet still machined from forgings and costly to build. The MP40 and the M3 are the war's verdict: the MP40 abandoned machined parts for stamped steel and a folding stock to enable dispersed, subcontracted mass production, and the American M3 went further still, a welded sheet-metal weapon designed expressly to undercut the Thompson's cost, with the suppressed variant built for OSS clandestine use.

The suppressed M3 was, to my surprise, the gun I enjoyed shooting most — I first saw it on screen as a boy in the early-1980s Mel Gibson film *Attack Force Z*, and never expected the cheapest weapon on the bench to be the most satisfying. Yet I had no difficulty controlling it, putting short bursts on target every time at representative ranges. There is an SE lesson buried in that experience. The M3's low cyclic rate of around 450 rounds per minute was chosen partly for economy and simplicity, and the suppressor adds mass and tames blast at the muzzle; together those traits make the weapon remarkably easy to keep on target. The "cheapest" answer was not a capability compromise. Correctly scoped to its requirement — close-range automatic fire — the producibility-driven design choices also happened to improve the user-facing performance. Cost reduction and capability are not always in tension.

The M2 Carbine sits deliberately outside this group. Its .30 Carbine round is a genuine intermediate cartridge — more than a pistol, less than a full rifle — and the weapon is gas-operated and select-fire. It points past the submachine gun toward the assault-rifle concept the Germans were pursuing in parallel with the StG44: a different requirement entirely, namely effective automatic fire to a few hundred yards for troops who do not need a full-power battle rifle.

Requirements Timing: G43 versus M1 Garand

The Garand and the Gewehr 43 are often compared as rival semi-automatic service rifles, but the more instructive comparison is when each program ran, not how each performs. The M1 Garand was the product of a long, deliberate prewar American development program; adopted in 1936, it put a self-loading rifle in the hands of the entire U.S. infantry from the war's outset. It is gas-operated with a rotating bolt and an eight-round en-bloc clip — the clip's audible ejection on the last round is a familiar quirk, but the design was mature and in volume production before the shooting started.

Germany, by contrast, entered the war committed to the bolt-action Kar98k and pursued a semi-automatic rifle only reactively, after encountering the Soviet SVT-40 and the Garand. The resulting Gewehr 41 program was crippled less by bad engineering than by bad requirements: the Army mandated that no gas port be drilled into the barrel, and that the rifle retain a manual bolt-action backup. Both were prescriptive design constraints masquerading as requirements, and they forced the

designers into the unreliable Bang-type muzzle gas trap. Only after capturing SVT-40 rifles did Walther adopt a conventional ported short-stroke gas system, producing the Gewehr 43 — with a 10-round detachable box magazine — in October 1943. The G43 was a sound rifle, but it arrived late, in modest numbers, and with build quality that eroded under late-war manufacturing conditions. The lesson is not that one rifle was better; it is that the Garand was ready because the requirement was set in peacetime, while the G43 spent the entire war catching up.

Doctrine Drives Architecture: BAR versus MG42

The starkest contrast on the bench is between the BAR and the MG42, because they answer the same question — where does a squad's automatic fire come from? — with opposite architectures rooted in opposite doctrines. The BAR was conceived in WWI for "walking fire," an individual automatic rifle fired from the hip or shoulder while advancing. It is gas-operated, fed from a 20-round magazine, weighs roughly 19 pounds empty, and has no quick-change barrel. Pressed into the squad-automatic-weapon role in WWII (the M1918A2 deleted semi-automatic fire and added a bipod and two cyclic rates), it remained a rifle asked to do a machine gun's job. I found it somewhat difficult to control: a full-power .30-06 cartridge in a shoulder-fired automatic is a handful, and its magazine capacity and fixed barrel cap how much sustained suppressive fire it can deliver before overheating.

The MG42 embodies the German Einheitsmaschinengewehr, or universal machine gun, doctrine: a single belt-fed, recoil-operated, roller-locked weapon that serves as a bipod light machine gun or a tripod-mounted medium gun by swapping its mount and sights. Its barrel is designed for changing in roughly five seconds to manage the thermal load of sustained fire, and it was deliberately laid out for stamping, pressing, and welding because it was designed by a firm expert in sheet-metal manufacture rather than gunmaking. German squad organization was built around the gun, with riflemen acting in support — carrying ammunition and spare barrels — the inverse of the American squad, where every rifleman carried a Garand and the BAR supplemented an already firepower-dense formation. Neither weapon is simply "better"; each is the correct implementation of a different operational concept.

A coda worth noting: the U.S. tried to reverse-engineer the MG42 as the T24, intended as a possible BAR replacement. The prototype failed because the .30-06 cartridge is roughly a quarter-inch (about 6 mm) longer than the 7.92×57mm round the gun was designed around, and the receiver was never dimensionally adjusted to accommodate it — the test guns fired a round or two and then choked on extraction and feeding. Lifting an integrated design onto a different cartridge is a re-engineering effort, not a translation.

The Two That Wouldn't Run: FG42 and StG44

Two of the rarest weapons at Battlefield Las Vegas were on the rack but not on the firing line: an FG42 and an StG44, both inoperable for want of parts. I regretted it, because each resolves — in opposite ways — a tension the rest of the bench only manages.

The FG42 is the most concentrated requirements statement of the war. After the costly Crete airborne assault in 1941, German paratroopers — who jumped with only sidearms while their rifles fell separately in containers — needed a single weapon that could serve as rifle, submachine gun, and light machine gun, light enough to carry on the jump yet chambered in the full-power 7.92×57mm cartridge. The December 1941 requirements list went further: roughly the length and weight of a Kar98k, a detachable magazine, optic-ready, an integral bipod and bayonet, inline recoil to limit muzzle climb, and — most elegantly — semi-automatic fire from a closed bolt for accuracy but full-automatic fire from an open bolt to prevent cook-off during sustained fire. That last feature is a model of how to resolve conflicting requirements: rather than compromise between accuracy and thermal safety, the design switches modes. The side-mounted magazine kept the profile low for prone fire. The result was one of the most advanced weapons of the war — and one of the hardest to build. Roughly 5,000 were made before the manufacturing base was disrupted, and the light weight made the full-power cartridge a handful in automatic fire. It is the cautionary half of the convergence story: ask one artifact to satisfy

every role and you may get something brilliant, complex, and nearly unproducible. Its feed mechanism later informed the U.S. M60.

The StG44 is the other half — the convergence that worked, because it changed the interface rather than the mechanism. German designers had concluded that most infantry fighting happens within a few hundred yards, so the full-power 7.92×57mm cartridge was more than the individual soldier needed and impossible to control in automatic fire from a shoulder weapon. Their answer was a new cartridge: the 7.92×33mm Kurz, a shortened intermediate round effective to roughly 300 meters. Mated to a select-fire, gas-operated rifle with a 30-round detachable magazine and a deliberately modest cyclic rate of about 500 rounds per minute, it produced controllable automatic fire from a single handy weapon — the synthesis the M2 Carbine only gestured toward. Built largely from stampings for mass production, and developed under the cover designations MP43 and MP44 partly to sidestep official objections to a non-standard cartridge, it became the first mass-produced assault rifle and the template for the AK-47 and essentially every modern infantry rifle since. Where the FG42 poured ever more capability into the full-power cartridge, the StG44 simply redefined the controlling interface — and in doing so dissolved the trade-off the rest of the bench spends its energy managing.

Bonus: The Barrett .50 — Engineering the Human Interface

The lone modern weapon on the trip was a Barrett M82, and it makes a fitting coda because it fires a thoroughly WWII cartridge. The .50 BMG was developed for John Browning's .50-caliber machine gun, fielded as the M2, which the U.S. used throughout the war — so there is a direct line from the bench of 1944 weapons to this 1980s anti-materiel rifle. What surprised me was the recoil: for a cartridge of that power, it was remarkably light — far gentler than the BAR, despite vastly greater muzzle energy.

That is entirely by design, and it inverts the lesson from the submachine guns. With the SMGs, choosing a low-energy cartridge made the architecture simple. Here the cartridge energy is fixed and enormous, so the engineering effort moves to the human boundary. The M82 is short-recoil operated — the barrel itself recoils about an inch against springs and a buffer — spreading the impulse over time, and a large muzzle brake redirects propellant gas to counter recoil, with the combination bringing felt recoil down to roughly that of a 12-gauge shotgun. Add a roughly 30-pound mass and a thick recoil pad, and the felt recoil — the load actually delivered to the operator — has been decoupled from the cartridge's energy by a deliberately engineered subsystem. Felt recoil is a designed output, not a given. The physics input cannot be changed, but the human-system interface load can be driven down by design.

SE Lessons for Practitioners

- **The cartridge is the controlling interface.** Fixing the cartridge fixes the energy the action must contain, and from there the operating principle, weight, and effective range cascade. Identify the analogous controlling interface in your own system and resolve it before elaborating the rest.
- **Producibility is a requirement, not an afterthought.** Four submachine guns answering one need ranged from hand-fitted machined art to welded sheet metal. Under attrition, design-for-manufacture became a hard constraint. Put it in the baseline rather than discovering it at production transition — and note, as the suppressed M3 shows, that the producible answer is not necessarily the lesser one.
- **Separate requirements from design constraints.** The German "no gas port" and "manual backup" mandates were solutions disguised as requirements, and they foreclosed the good answer until removed. State what the system must do; reserve "how" for genuine constraints.
- **Capability timing is a program risk set years early.** The Garand was ready because the United States committed in peacetime; the G43 never stopped catching up. When a capability must exist is a decision you make long before you feel its absence.

- **Architecture follows CONOPS.** The BAR and MG42 were not points on one axis of goodness; they implemented different squad doctrines. Validate the operational concept before judging the artifact, or you will optimize the wrong thing.
- **An integrated design does not copy for free.** The T24's drawings captured the explicit geometry but not the tacit dimensional fit to a longer cartridge. Re-baselining a mature design onto a new cartridge or manufacturing system is engineering work, and should be scoped as such.
- **The human-interface load is a designed output.** The Barrett's felt recoil was engineered down to a fraction of what its cartridge energy implies. Where a physical input is fixed, the burden it places on the operator is still a design variable — provision for it deliberately.
- **A system is only as available as its spare-parts pipeline.** The two most interesting weapons of the trip never fired a shot, because no parts were on hand to keep them running. Rare, complex designs degrade into static displays without a sustainment tail. Availability is a lifecycle property, not a delivery-day one — plan the spares and logistics alongside the design, not after it.

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