

SATS

Vehicle Technologies - Airframe

Lean Design & Manufacturing

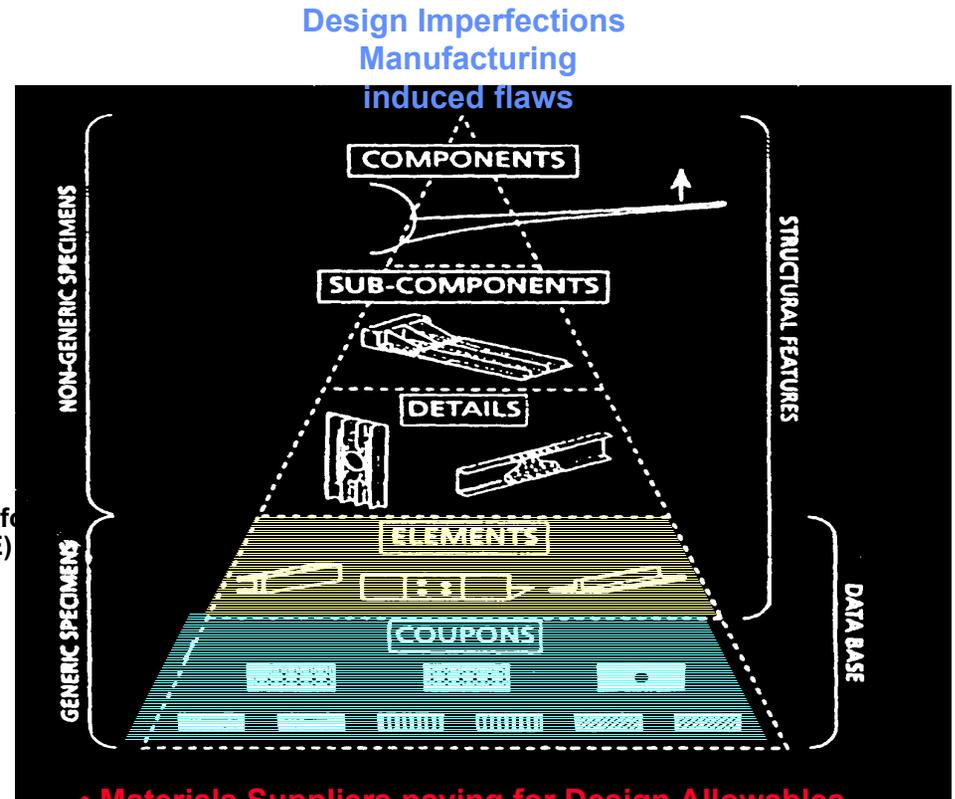
**Design
for
Manufacturing
& Assembly**

**Small Aircraft Transportation System
Planning Conference
June 21-24, 1999 Hampton, Virginia**

W. Tom Freeman

Building Block Substantiation for Adv. Mtl. Forms, Mfg. Processes & Design Concepts

- **Why Building Blocks?**
 - Material & process control
 - Analysis validation
 - Risk mitigation for design-specific detail
 - Variability & environmental factors for full-scale test substantiation
- **What is the right scale to start?**
 - Most efficient path
 - Variability vs. scale
- **Proposed engineering approach**
 - **Start at the product rather than material level**
 - Breakthrough savings (mfg. tech. &/or low-cost mtl.)
 - Adv. analysis based on strain softening & dissipated energy to generate failure envelopes in forms suitable for engineering analysis (VMT shell & beam analysis or FE)



No AGATE Research

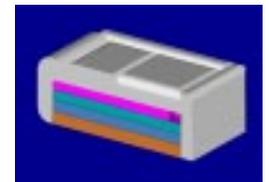
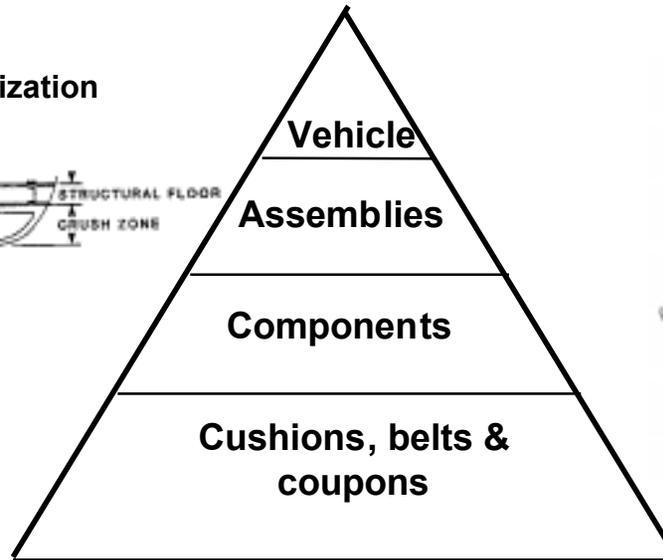
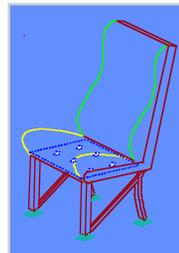
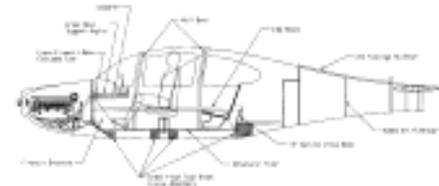
Start FY 2000

Complete

RITA notched data

Building Block Substantiation for Crashworthiness Certification

- **Why Building Blocks?**
 - Analysis validation
 - Risk mitigation for design-specific detail
 - Variability factors for full-scale test substantiation
- **Proposed engineering approach**
 - **Start at the product rather than material level**
 - Breakthrough savings (cert. &/or flow-time)
 - Adv. analysis based on component characterization
 - A true Systems Approach



SOTA 2001

Low-cost fuselage design featuring:

- **Impenetrable Occupant Volume Capsule**
- **Energy absorbing structure below cabin floor**
- **Non-scooping firewall**
- **Crashworthy engine mount & nacelle**
- **Delethalization interior with airbags & restraints**

Cirrus Design Corporation SR20

- FAR Part 23
- 184 mph
- 4 place
- unpressurized
- foam sandwich construction
- hand layup - prepreg
- vacuum bag / oven cure



LANCAIR IV-P KIT COMPLETE AIRFRAME \$100,800.00

Lancair 4P

- Kit - Experimental
- 335 mph cruise speed @ 24,000 ft
- 4 place
- pressurized
- honeycomb sandwich construction
- hand layup - prepreg
- vacuum bag / oven cure



Continental TSIO-550E1B
6 cylinder, 350 hp @ 2700
rpm \$54,900.00

Props

Hartzell aluminum or MT
composite constant speed
props are recommended.
Spinner, backup plate and
mounting plate included.
MTV-14-D 4-blade for TSIO-
550, 75" \$11,240.00

- **Order of Magnitude of Airplane Sales**
 - **Used - 30,000/ yr**
 - **New kits - 1 to 2X Certified**
 - **New certified - 1500 to 2000**
 - » **Everybody that can afford a Rolls Royce has one**
 - » **Pilots license cost = chauffer cost**
 - » **Fractional ownership of a Rolls**
- **Technology today**
 - **Emphasis on product design with limited number of low volume suppliers**
 - **All Technology adequate for the enthusiast**
 - **5 Years of AGATE -**
 - » **Outstanding Technical Achievements**
 - » **Perceived increase in safety**
 - » **Cost more?**

- **Pillar II - Revolutionary Leaps?**
 - **Turbine**
 - » “Turbines will do for GA what they did for Commercial Aircraft”
 - **Computer Hardware & Software**
 - » Intel 5 ghz processor

SATS Investment - Bold Cost Reductions

- **Compelling Vehicle Price**
 - » Henry Ford of GA
 - **Regulatory Revitalization Partnership**
-
- **SAE Aerospace Manufacturing Technology Conference & Exposition**
 - Building the 21st Century Global Aerospace Manufacturing Enterprise

- **Manufacturing Progress**
 - Craft - Automated - Lean - Just in time - Kaizen
- **Product Design Focus**
 - » **Silos of engineering, manufacturing, cost estimation, etc**
 - » **Serial Process**
 - **When aero is done - structures starts - manufacturing & cost estimation last**
 - » **Craft production assembly of a collection of handmade parts from low volume suppliers**
 - » **Sequential manufacturing processes - bottlenecks throttle the whole factory**
- **System Design Focus**
 - » **Lean design and manufacturing principles with value chain and supplier initiatives.**
 - » **Parallel Process**
 - **CAD 3D model shared with all suppliers and modified real time**
 - » **Best supplier from high volume industries**

- **Design for**
 - **Improved Safety**
 - » **Crashworthiness**
 - **Automation**
 - **Supportability & Repair**
 - **Reliability**
 - **Lean Manufacturing & Assembly - minimum waste**
 - **Min parts, processes, tools, and assemblies, parts are self-aligning and self-fixturing, no threaded fasteners, less inventory, less QA, best suppliers selected (internal vs external)**
 - **Lean design - Lean engineering - Lean thinking**
 - » - **quest for ruthless simplicity**
 - **Lean suppliers - Supply chain management**
 - **Value chain - Value mapping**
- **Benefit**
 - » **Maximize Margin**
 - » **Fertilizer for growth & catalyst for new products**
 - » **Affordable Products**

Chrysler VP of Manufacturing- Dennis Pawley

SATS

Lean Design & Manufacturing

- From govt. bailout to highest margin in the industry
- Managed 90,000 people in 54 plants
- Chrysler Operating System - Bridges Philosophy and Reality
 - » No product is technically successful unless it's financially successful
 - » Culture change - the battle for peoples minds
 - Lean manufacturing pulls the rest of the corporation
 - » Manufacturing *push org* to a **pull org**.
 - *Stage 1 Necessary evil to make stuff*
 - *Stage 2 Competent - adhere to industry standards*
 - **Stage 3 Potential competitive asset**
 - **Stage 4 Strategic weapon - delivers competitive advantage**
 - » Design must select robust, capable and in-control processes
 - » Everything contributes to bottom line
- Retired from Chrysler - President of Performance Learning
- Interested to assist with SATS

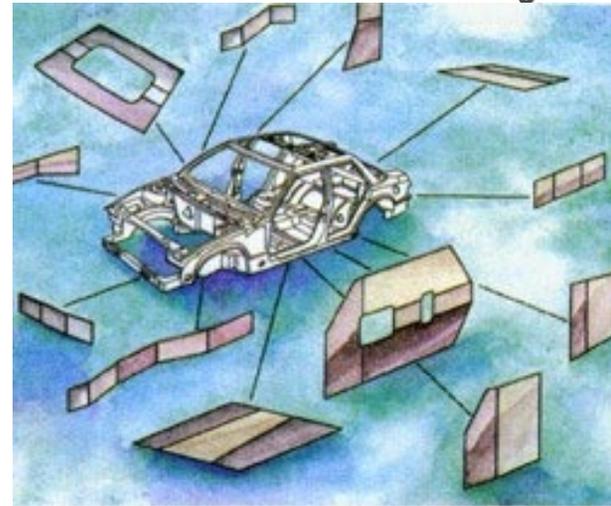
- “The design process is the only step in the product cycle where **value** and profit **can be created**”
- “**Product design**, which accounts for only 5% of a product’s total cost, **actually dictates 70% of the products total manufacturing cost and 90% of it’s life cycle cost.**”
- “Design Engineering has much more leverage to reduce labor costs at the beginning of the design process than industrial engineering has at the end of the process”
- “**Material, tooling and overhead savings from eliminating parts dwarfs the savings in assembly labor**”
- “Design determines not only product manufacturability and quality, but reliability and serviceability as well”

- “Designs are a life sentence to the factory floor”
- “To **leap-frog** ahead of your competition, you must break the *what worked for us before will work again* syndrome.”
- “**The team must be multi-functional and include profound knowledge from people outside the normal pool**” Time and time again the best ideas come from outsiders who couldn’t possibly know anything that would help.
- “**The Learning Curve is a crutch for a bad design**”
“Cars used to take 6 months to get to line speed - new designs get to line speed in one day.”
- “**Honor the competition to find out how you can leapfrog them.**”
- Interested to assist with SATS

SATS

ALCOA & Audi A8

Lean Design & Manufacturing



The use of tailor welded blanks results in weight and cost reductions by enabling engineers and designers to put strength or thickness only where it is needed.



**Selling
Price
=\$70K
=\$19/lb**



Automotive Research

SATS

Consortium of 30 steel companies invested \$20M to “prove steel’s preeminence” ULSAB



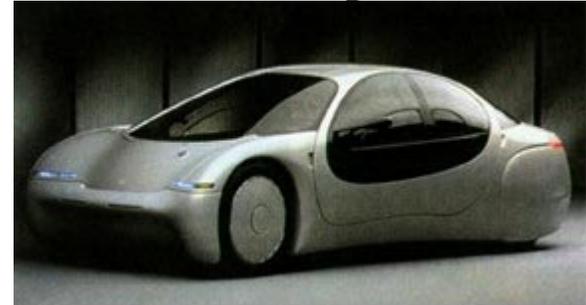
Steel \$989/451lbs = \$2.20/lb



Aluminum



Lean Design & Manufacturing



Made entirely from carbon fiber composites, General Motors' Ultralite body structure weighs only 420 pounds. The carbon fiber material is half the weight of aluminum -- yet has two times the stiffness. It also has one-quarter the density of steel with slightly better stiffness. However, the material cost alone for the Ultralite structure was approximately \$13,000 -- several times the cost of aluminum, steel or fiberglass.



2 Piece (50+Parts)
Material / Labor cost
235 lb (ALCOA?)

Orders of Magnitude

SATS

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- Car Body \approx \$650 STEEL \approx \$5000 Alum \approx \$25,000 Gr Comp
- GA Fuselage \approx \$24,000 Alum \approx \$50,000 GI Comp
- Car Assembly Labor $<$ 20 mh Steel
- GA Assembly Labor \approx 500 mh Alum \approx 1500 mh Comp
- Car Total Labor \approx 150 mh Steel
- GA Total Labor \approx 1200 mh Alum \approx 2,500 mh Comp

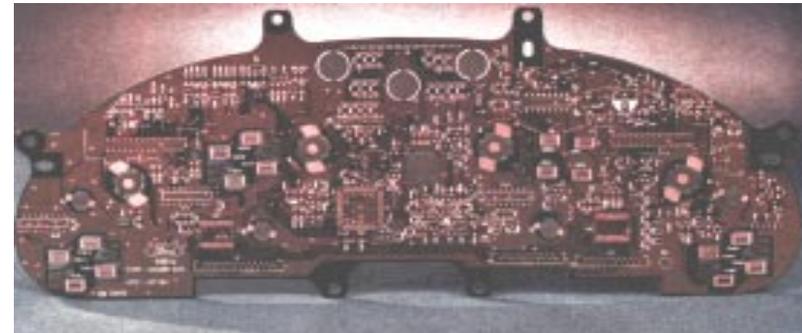
- Minivan Steel Price/lb \approx \$5 \approx 250,000/year volume
- Prowler Alum Price/lb \approx \$15 \approx 1,500/year volume
- Audi A8 Alum Price/lb \approx \$19 \approx 10,000 year volume
- Viper Comp Price/lb \approx \$20 \approx 1,500/year volume
- GA Alum Price/lb \approx \$100 \approx 200/year volume

- Automotive Research must meet severe cost restraints.
- **High Value GA parts offer profit potential that's higher than sports cars.**
- **Would automotive suppliers produce to GA specifications?**
- GA outlet until experience, tooling amortization, and volume reduce cost.
- GA companies should participate in PNGV, SAE, etc. - Near Term customer for auto research products

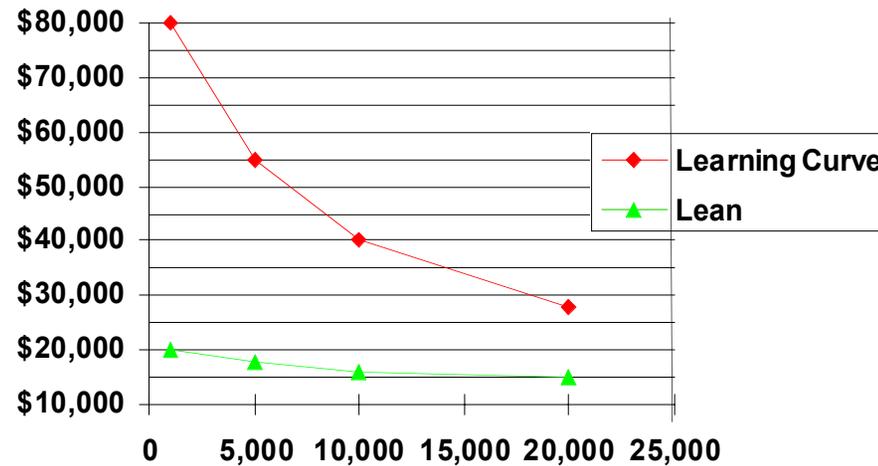


SOTA

**Thermoplastic Instrument Panel
Circuit Boards**



**Digital Dashboard - "Motherboard"
Standards**



Learning Curve vs Lean Thinking

- **Paradigm Shift from Cost to Profitable Growth**
 - Internal Efficiency extends to External Trading Effectiveness
- **Velocity increases as Internet compresses Planning and Execution cycles**
- **Trading Relationships become critical**
- **Information replaces Inventory**
- **Solutions eclipse Products**

- **Foster environment for continual safety improvement & focused funding for increased safety**
- **Individual company serial learning vs multi-industry lessons learned collaboration**
 - **Must facilitate tech transfer - travel- consultants- touring facilities, etc.**
- **Design & Simulation center @ a university to provide expert training for fractional ownership of world class lean design capability**
 - **System Design Incubator & Lean Lessons Learned Repository for cumulative knowledge, simulation tools, etc.**
 - » **Convert 4 year education into an internship for students**
- **CATIA Knowledgware**

- Multidisciplinary design optimization tools with lean thinking - ISE Integrated Synthesis Environment tools
- Airbus Service Company President & COO
 - “Objective of lean enterprise plan is to transform the organization into a world class design & manufacturing facility that produces high quality affordable products **maximizing the principles of flow, density, & velocity.**”
- COSTRAN
- Manufacturing technology funding for automation and machine tool development for composite processes
- GA optimum testbed for cost effective prototyping new technology
- Technology Incubation - “When the Markets Ready”
 - Design SATS Vehicle as an integrated system with lean principles
 - Economic Leapfrogging
 - Bankrolling Change - Travel, Suppliers, auto conventions, PNGV, etc.