

# BMW i3 Teardown Analysis Study:

Reports Summary and Pricing Detail





***“Experience without theory teaches nothing!”***

**Munro & Associates’ BMW i3 Report is an extensive lesson in ‘theory of design’! This powerful report is an irreplaceable instructional tool that will not only guide your engineering team by the hand through the incredibly important HOWs and WHYs of automotive design but will also reveal the financial impact a design can have on the company’s bottom line!**



## Study Highlights

The BMW i3 is celebrated for being the first mass produced electric vehicle to extensively feature carbon fiber. The cost and methodologies related to the assembly and fabrication process, especially those of the carbon fiber life module, are of high interest. In addition, the BMW i3 utilizes the state-of-the-art battery technologies featuring an innovative modular design. Combined with an optional range extending engine (REx), the system sets new industry standards. Munro's unique software methodology, [Design Profit®](#), allows us to provide detailed assembly, processing and financial insights into these and other key areas of interest.



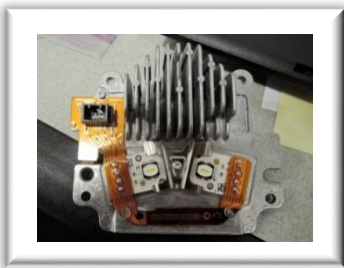
**Carbon Fiber Life Module:** Carbon Fiber Life Module components, materials and processes are disassembled, analyzed, documented, cost modeled and summarized. Detailed information regarding the cutting, forming and molding of carbon fiber sheets as well as their assembly into single body structural units will be provided. In addition both the materials and costs for adhesive fastening of the body structure to the frame will be provided including the number and size of joints, adhesive types, and the types of machines used for adhesive application.



**Battery:** The high voltage battery pack, battery management electronics housed within the battery pack, battery cells, and cables, assemblies, and sensing wire harness are all disassembled, analyzed, documented, cost modeled and summarized. Fastener types, properties and fastening techniques are all analyzed, documented, cost modeled and summarized. All internal components of the battery are analyzed and cost modeled including the electrolytes and active materials used in the electrodes. Full detail of the electrode manufacturing process, including mixing of active materials, coating, drying, slitting and compaction is provided. In addition, all related electronic control modules and printed circuit boards are analyzed.



**REx System:** The REx system is completely disassembled, analyzed, documented, cost modeled, and summarized. The study includes the removal and disassembly of the REx engine, electric generator harnesses and mounting hardware. The engine, fuel and exhaust systems as well as the engine accessory components are fully reviewed for cost of materials, fabrication and the assembly and fastening processes. Complete engineering, processing and cost information on related electronic system control modules and harness components are provided, as is full detail on the materials and installation of any associated noise abatement components.



**Electronics:** Integrated vehicle electronics are disassembled, analyzed, documented, cost modeled and summarized. TechInsights Teardown.com worked with Munro & Associates to identify, cost and document circuit designs, analyze the structure and board layout, and provide detailed Bill of Materials for over 70 boards found in the i3. Key areas of focus include the infotainment system and instrument cluster, the Advanced Driver Assistance Systems (ADAS), power train systems, and body control systems.





## Report Detail Overview

Zone reports will be made available individually and will also be packaged into larger System Bundle reports to provide all information pertinent to the vehicle systems:

- Zone 1 – BODY
- Zone 2 – Exterior
- Zone 3 – Rolling Chassis
- Zone 4 – Battery System
- Zone 5 – Electronics
- Zone 6 – Cooling Pack and HVAC
- Zone 7 – Driveline
- Zone 8 – REx System
- Zone 9 – IP and Interior Trim
- Zone 10 – Seats

Several metrics, key points, eye catching features, and detailed assembly and manufacturing steps are illuminated to the reader throughout the reports.

See next page for more details:

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Total Part Count:	18
Discrete Part Count:	18
Fluid Part Count:	0
Sub Count:	6
Step Count:	46
Total Fastener Count:	0
Discrete Fastener Count:	0
Fluid Fastener Count:	0
Tool Count:	0
Inspect Count:	0
Operation Count:	13
MultiTouch Count:	6
Ergo Danger Count:	0
Poka Yoke Count:	0

**MUNRO & ASSOCIATES, INC.** BMW i3 Teardown and Benchmarking Study

### Outer Cell Winding Asm

**MUNRO & ASSOCIATES, INC.** BMW i3 Teardown and Benchmarking Study

### Key Points of Interest

#### The Battery Pack

(Included in Zone 4)

- As the image below indicates, foresight and customer consideration were key ingredients used by BMW in the battery pack's unique, 8 module, design. In the event of a battery cell failure, an individual 45 volt module can easily be replaced eliminating the costly need to replace the entire battery pack.
- Detailed costing of all major components is performed with Munro's proprietary software, [Design Promis](#). Pricing for commodity items (i.e. fuses, contactors, substrates, chemicals, fasteners) are assigned from our Knowledge Library.
  - Estimates are based on actual parts.
  - Photos: Background on 100mm grid paper.



**MUNRO & ASSOCIATES, INC.** BMW i3 Teardown and Benchmarking Study

### Key Points of Interest

#### Electronics

(Included in Zone 5)

Excerpt from Electronic Circuit Board Report

Component Type	Percentage
Integrated Circuits	48%
Connector Components	18%
Passive Components	8%
Small Active Components	8%
Modular & Odd Components	1%
Substrates	7%
Insertion	4%
Card Test	4%

### Passive Discrete Components

Location	Qty	Functional Description	Package		Estimated Costs	
			Form	Pin Count	Each	Total
Main Board, Sec 1	1	Capacitor	Tantalum / Niobium Small	2	\$0.050	\$0.050
	1	Capacitor	Electrolytic Small	2	\$0.040	\$0.040
	115	Small Passive	Cap. Res. Ferrite	2	\$0.004	\$0.472
Main Board, Sec 2	6	Capacitor	Tantalum / Niobium Small	2	\$0.050	\$0.300
	1	Cap	SMT Small	4	\$0.050	\$0.050
	153	Small Passive	Cap. Res. Ferrite	2	\$0.004	\$0.612
<b>TOTAL \$</b>	<b>280</b>			<b>562</b>		<b>\$1.52</b>

**MUNRO & ASSOCIATES, INC.** BMW i3 Teardown and Benchmarking Study

### Key Points of Interest

#### Electronics

(Included in Zone 5)

Zone 5 in the BMW i3 Report details the Electronics and contains the following: System Electronics, Infotainment, Body Control Module, and Fuse Box. Each of the various functionalities of the Electronics will be highlighted in the main report. Each detailed analysis report will be located in the associated Zone appendix.

(Sample)

#### Product Description

The Control Board is a component of the Battery Module designed into the BMW i3 hybrid electric vehicle. The primary function of the Control Board is to monitor battery status and send fault messages to a central processor located in another part of the vehicle. Its key devices include a Freescale MC9S12P64 16-bit microcontroller and Linear Technology's LTC6801G battery fault monitor and LTC6802G-2 battery stack monitor. Support consists of Texas Instruments' LM2904AVQ dual op-amp and CD74HC4538M dual monostable multivibrator along with an LM2903YDT dual comparator from STMicroelectronics. An Infineon TLE7273-2EV50 provides general voltage regulation, while Analog Devices supplies the ADR366 precision voltage reference.

- 1. Linear Technology LTC6802G-2 Battery Stack Monitor
- 2. Freescale MC9S12P64 CAN Transceiver
- 3. Analog Devices AD9442 Dual Digital Isolator (Clock Pkg.)
- 4. Linear Technology ADR366 Precision Voltage Reference
- 5. Linear Technology LTC6801G Battery Fault Monitor
- 6. Texas Instruments CD74HC4538M Dual Monostable Multivibrator
- 7. Infineon TLE7273-2EV50 Voltage Regulator



## The most comprehensive teardown and benchmark analysis available of the BMW i3!

While the BMW i3 has, and will continue to be, the subject of a myriad of different analyses and reports, only Munro will provide detailed findings that breakdown and detail every manufacturing cost.

Munro has a long history of producing [teardown benchmarking](#) studies for both the public sector and private clients, however the i3 study will mark the first time that these types of reports will be made available for general distribution.

The i3 study will tap into all facets of Munro's deep [knowledge of technologies](#), materials and manufacturing processes. The company is uniquely positioned to analyze and report findings on the i3's ground breaking use of carbon fiber as well as other light-weight materials, metal forming and molding. Munro's extensive experience with powertrain and battery technologies will also be leveraged to provide a comprehensive analysis of the BMW i3.

## This study includes:

- A 10 Zone complete cost, assembly, and materials-analysis for all parts specific to a zone or system.
- Eye catching features and functions
- A Vehicle Fit and Finish Quality Audit (FFQ) report Audit.
- Comprehensive analysis of the i3's carbon fiber manufacturing and assembly process.
- Detailed reporting of the battery cost and construction.
- A complimentary single license of Munro's proprietary Design Profit® software which provides the purchaser the ability to print Cost Maps®, indented Costed Bill Of Materials (CBOM).
- Copies of, or links to, any known BMW public domain articles and videos.

## Study Overview

In late 2014 Munro & Associates, a global leader in manufacturing costing and benchmarking, began the monumental challenge of producing an industry exclusive, highly detailed, teardown and [benchmark study of the revolutionary BMW i3 Electric Vehicle](#). Using proprietary advanced quality, assembly process and costing software, Design Profit®, Munro disassembled and meticulously analyzed the entire vehicle, system by system, at its world class benchmarking facility in Auburn Hills, Michigan.

**MUNRO & ASSOCIATES, INC.**

Process, Methods & Tools

Service Software

Design Profit Modeling

Excel C-BOM #1 #2 #3 #4 #5 #6 #7 #8

## Why Choose Munro & Associates?

**Leader of Lean Design®**

- Father of DFM® and Lean Design®
- Creator of Design Profit®, Cost Map®, and Munro Costing Solutions
- Many Industry accolades from highly successful project results since 1988

**Solution Provider for Cost Reduction and Quality Improvement**

- Solutions such as Level 1 technologies which can be applied immediately and/or Level 2 technologies which are valid in the market with some level of investment
- Long-term solutions such as Level 3 technologies which are highly innovative and patentable ideas

**BI<sub>2</sub>C Industrial Knowledge Transfer**

- Munro possesses cross-industry knowledge called "Tech Transfer"
- Supplier information (materials, processes, cost data, cost models)
- Benchmarking references and database

**Both Product and Service Available**

- Consultants' deep industrial knowledge of all industries
- Proven Lean Design® Methodology with Design Profit® as a software platform
- Munro delivers both consulting services with proven results utilizing Design Profit® software

**We Know All Industries**

- We have deep knowledge of the your industry and suppliers

**We Know Where Problems Originate**

Cost and quality are commonly discussed everywhere. But many times it is recognized in different languages using different terms. Munro knows where all of these issues come from and what to do to be more competitive.

**We Know What the Benchmarking Center Is for Your Industry**

- Munro understands what other industry leaders are doing in costing and cost management
- Munro will deliver a common language platform (cost, quality, customer value) to use across all your different BU teams and suppliers

**We Know What To Do and How to Do It**

- Platform for cross-functional team work
- Process-centric approach with an strong system using Munro consultant support who can supply training (Design Profit® and costing) and coaching

leandesign.com



*BMW i3 Report as Featured In:*

**DesignNews**

**MOTOR TREND**

**Forbes**

**WALL STREET  
JOURNAL**

**Bloomberg  
Business**

 **REUTERS**

# *Who Says?*

**“Engineering consultant Sandy Munro has a shop in suburban Detroit where he takes apart cars, seeking clues to design and manufacturing tricks he can sell to manufacturers eager for a cram course on their competition.”**

**– Joseph B. White, Wall Street Journal**

**“...rest assured, a lot of people in the auto industry want to know its secrets... [Munro delivers] a detailed analysis of the costs and processes involved, right down to the individual nuts and bolts used.”**

**– Joann Muller, Forbes**

**When such “disruptive” new cars come to market, competitors are often quite curious about what makes them tick... some that do will also engage the talents of Michigan-based cost-estimating and benchmarking consultancy Munro & Associates to tackle the most bleeding-edge projects. Chinese automakers have been steady customers of late, and Munro claims to have helped Indian upstart Tata trim 1,750 pounds (and considerable cost) out of its home-market Aria crossover.**

**– Frank Markus, Motor Trend**



*BMW i3 Report as Featured In:*

**DesignNews**

**MOTOR TREND**

**Forbes**

**WALL STREET  
JOURNAL**

**Bloomberg  
Business**

 **REUTERS**

Below is a small sampling of the prestigious publications, websites, and blogs buzzing with anticipation of the Munro & Associates BMW i3 Report.

**For A Full List of Videos And Articles Click [Here](#).**

• [The Future Of Cars Looks Very Different](#)

Wall Street Journal, Dec.

• [Unlocking The Secrets of BMW's Remarkable Car of the Future](#)

Forbes, Jan.

• [Munro Discusses Groundbreaking Technology Finds from BMW i3 Teardown at Plastics in Automotive Conference](#)

Bloomberg, Jan. 14

• [Reverse Engineering The BMW i3](#)

BMW Blog, Jan. 5

• [Is BMW's i3 Profitable](#)

Motor Trend, Jan. 30

• [BMW i3: The 'Most Significant Vehicle Since the Model T'](#)

Design News, Feb. 10

• [Munro & Associates CEO Offers 'A Peek into the Future' of Manufacturing at MFG Meeting](#)

Reuters, Mar. 6

• [The BMW i3: Deconstructed](#)

Automotive Design and Production, Mar. 2

• [BMW i3 "one of the best engineered vehicles on the planet"](#)

Automotive Purchasing, Jan. 15

• [The Most Advanced Vehicle On The Planet Taken Apart And Reverse Engineered](#)

Charged – Electric Vehicles Magazine, Jan. 8

• [Is Carbon Fiber Gimmick, Or Paradigm Shift?](#)

Repair Driven News, Mar. 26

• [Teardown Reverse Engineering The BMW i3 Technology](#)

Ecemento, Jan. 7

• [Us Company Can Reverse Engineer The BMW i3 To Tell You Its Secrets](#)

In Auto News, Jan. 5

• [BMW i3 Electric Car Teardown: Profitable At 20,000 Units](#)

Green Car Reports, Jan. 5

• [BMW i3 Called Most Revolutionary Car' Since Ford Model T](#)

Autoblog, Jan.

• [2015 BMW i3 Profitable After Just 20,000 Cars](#)

Transport Evolved, Jan. 5

• [宝马i3和特斯拉s代表汽车业的未来？](#)

US/China Press, Dec. 22





# FAQ (Frequently Asked Questions)

- *How long did the study take?*

*The study took 11.5 man-years*

- *What was the cost to Munro?*

*Well over \$1,600,000*

- *Why did Munro perform this study?*

*Munro is a world class consulting company that needs to keep up with cutting edge technology*

- *What was not analyzed?*

*Nothing was excluded*

- *How accurate is the Costing and Manufacturing Data?*

*The EPA says Munro costing is “Irrefutable”*

*“Munro estimates are within 1% of our manufacturing costs!” Chinese OEM CFO*

*“You are 3 cents off on a part that we know costs \$123.64!” Tier 2 Powertrain Supplier*

*WOW! You are at \$1,016.59 and we have a price of \$1,021.15. Tier 1 supplier costing a Mexican build.*

- *How can I be sure these numbers are accurate? Who says they are accurate?*

*“Your numbers are too close to be estimates! Who gave you this data?” A BMW representative.*





## FAQ (Frequently Asked Questions)

- *How deep was Munro & Associates analysis on the unique carbon fiber reinforced polymer (CFRP) material used on the BMW i3 body. In other words, how much aluminum in proportion to carbon fiber reinforced polymer (CFRP) was used? How were the proportions calculated – by the entire vehicle or sub-systems? Are the material compositions laid out in detail and specified? General information is interesting but not beneficial to us. We must have specifics.”*

*Our ‘deep dive’ examination into the i3 materials has surpassed any previous analysis performed by Munro & Associates in our 29 year history. In fact, every single part has been painstakingly investigated and detailed in the BMW i3 report including analysis on the ‘super’ adhesives used and even the chemical composition of the batteries.*

*To date, we have upwards of 196,000 manufacturing steps documented including a staggering 54,000 parts (31,000 mechanical and 23,000 electronic/electric). The i3 Report is in excess of 23,000 digital pages.*

*But we didn’t stop there...our team partnered with **Teardown.com** to tear into the i3’s advanced electronics right down to the circuit component level offering you detailed imagery on what makes the BMW i3 tick.*



# FAQ (Frequently Asked Questions)

- *Was BMW involved in the study?*

*No BMW proprietary costs or any BMW suppliers quoted costs were used in this study. Contact to material suppliers was limited to general costs not BMW negotiated costs.*

- *Is there any BMW propriety (stolen) IP in this report?*

*All data was acquired through legal means.*

- *This car had components built all over the world. Did Munro use costing centers for only USA and European manufacturing data?*

*Every aspect of manufacturing was investigated and documented in the BMW i3 Report. Through our extensive research we compiled data on major global suppliers and Tier 1, 2, and 3 manufacturers including cost calculations based on the suppliers/manufacture's Country of Origin.*

*We discovered BMW had suppliers in Morocco. To ensure the integrity and accuracy of our report we developed cost models specifically for the northwest region of Morocco. Furthermore, our distinct Cost Models are accurate accounting for labor (OEM & Suppliers) as well as factory floor costs including machine burden rates, utilities cost, factory floor cost, taxes and SG&A.*

- *How big is the report?*

*The full report is over 23,000 pages with 54,000 parts process analyzed and costed.*



## FAQ (Frequently Asked Questions)

- *I have heard Munro has videos of many parts being built. Is this true? Are they also available? “We are hoping that the i3 report is technology oriented so that we can use it for accurate benchmarking. Does the report include analysis on materials, processes, cost, supplier system and all systematic performance tests?” Is there backup documentation provided?*

*The BMW i3 Report includes detailed engineering analysis on materials, processes, cost, and supplier systems. With regards to systematic performance tests we have listed numerous credible reports completed by US government agencies, reputable publications and insurance companies. The web links for these are listed in the Appendix and Bibliography section of the Report.*

- *Our company lacks the necessary experience to confidently benchmark a vehicle with this high caliber of technology. How can the i3 Report help us?”*

*The Munro BMW i3 Report is the perfect solution for any company tired of playing ‘catch up’ with their competitors. The BMW i3 Report will instantly catapult your company to the forefront of your industry as you digest, understand and implement the most advanced, innovative, and inspiring technology in the automotive world today!*



## **LEGAL DISCLAIMERS AND SALES CONDITION**

- *How can I see the sample report before purchasing?*

*Please contact your regional Munro sales person. They can provide sample information in digital PDF format (NOTE critical data will be hidden in the sample)*

- *Is this report allowed to reproduce, distribute, disseminate, photocopy, fax, transmit in the same organization when they purchased?*

*It is not allowed legally to reproduce, distribute, disseminate, photocopy, fax, transmit, sell, publish, or send this material, or any portion thereof, by any means without the express written permission of Munro & Associates Inc. under penalty of law.*

- *If there is a request for someone from Munro to visit and to explain in detail the report, is it possible to do or is it included in the price of report?*

*No it is not included in the price of report. Munro will visit and answer questions if the customer pays for the travel cost and a daily fee for the visitor. The request will be discussed and contracted separately before the visit.*

- *If there are few but specific questions on the content of report, is it possible to support a phone or e-mail communication?*

*Yes, please contact the local area sales person and we will respond with our answers.*



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