ZF S-Cam4 Mono and Tri Camera
Automotive Camera for Advanced Driver Assistance Systems
System report by Wilfried THERON
May 2019 – Version 1
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Executive Summary

This full reverse costing study has been conducted to provide insight on technology data, manufacturing cost and selling price of the S-Cam4 Mono and Tri Camera supplied by ZF Friedrichshafen AG (website).

These cameras feature the Omnivision CMOS image sensor, which demonstrates the shift in the procurement strategies of ZF and Intel Mobileye. In fact, the use of the latest Mobileye EyeQ4 Vision Processor allows new sensors to be used and makes the S-Cam4 one of the smallest and lightest products in its category.

Based on a teardown of the system, this report details a complete bill of material and describes the electronics and housing assembling. Moreover, a specific report describes the camera’s manufacturing and packaging processes. It presents also a detailed physical analysis of the CMOS image sensor, with a cross-section of the complete camera modules.

These reports also include a comparison with the previous version in the S-Cam series, the S-Cam 3. It estimates the manufacturing cost and selling price for both the mono and tri-camera.

The teardown and the cost analysis of the System On Chip (SOC) is available in the related report “Mobileye EyeQ4 Family”.

Company Profile

Physical Analysis

Cost Analysis

Manufacturer Price

About System Plus
Reverse Costing Methodology

The reverse costing analysis is conducted in several phases:

- **The initialization of the analysis**
  - Pictures of the elements to be studied.
  - Identification of the components.

- **Description of the material in the “SYScost+” software**
  - Creation of an “estimation project” of the studied board with SYScost+ software.
  - Construction of the Bill of Material (BOM).

- **Assessing the material**
  - Searching for the price of each reference among distributors and manufacturers.
  - Assessing the cost of the PCB and of the unaccounted references (unknown by distributors).
  - The BOM is valued with SYScost+ : price simulation according to the requested quantities.

- **Assessing the assembling and test phases**
  - Assembly and test lines are modeled with the SYScost+ software.
  - The assembly and tests costs are estimated.

- **Production cost & selling price**
  - Estimation of the production cost & selling price.

- **Report**
  - A report is edited.

SYS.cost+®, is a software tool developed by SYSTEM PLUS CONSULTING to calculate the cost of electronic boards. More information on the software can be found at [www.systemplus.fr](http://www.systemplus.fr).
Views and Dimensions

Views of the Camera.
Camera Opening

System opening

- Camera Image
- Sensor (CIS)
- Lens Module
- Electronic Board (Top side)
- Screw Torx M2x6mm (x2)
Electronic Board – Top Side – Main Components Markings
## BOM Cost – Electronic Board (1/3)

<table>
<thead>
<tr>
<th>Part Reference</th>
<th>ArticleQty</th>
<th>Description</th>
<th>Package</th>
<th>Pin nb</th>
<th>Manufacturer</th>
<th>Datasheet</th>
<th>Side Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

*Note: The table contains details for the Electronic Board with specific quantities, descriptions, and costs.*
Details of System Added Value (AV) Cost

The assembly steps of the system are assumed to be done in xxx.

For each operation, we have considered the time of realization and quantified the manufacturing cost depending on the country where the system is manufactured.

For the complete system, the total manufacturing time is xxx seconds, which is the necessary time for assembling and testing the system. The assembly and test cost is of $xxx.
## Manufacturing Cost Breakdown

### ZF S-Cam4 MonoCam

<table>
<thead>
<tr>
<th>Article</th>
<th>Qty</th>
<th>ASSEMBLY COST</th>
<th>MATERIAL COST</th>
<th>MANUFACTURING Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>1</td>
<td>$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic Board</td>
<td>1</td>
<td>$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Total Manufacturing Cost is estimated to $xxxx including $xxx for Material Cost (xx%) and $xxx for Added Value Cost (xx%).
Estimation of the Manufacturer Price

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Quantity</th>
<th>Manufacturing Location</th>
<th>Material Cost</th>
<th>Scrap</th>
<th>Supplying</th>
<th>Total Material Cost</th>
<th>Assembly Cost</th>
<th>Manufacturing Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1,000,000</td>
<td></td>
<td></td>
<td>1.00%</td>
<td>5.00%</td>
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<td></td>
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</tbody>
</table>

The bill of material (BOM) cost is estimated to $xxxx for the Camera.

To this, we must add some scrap costs and component supplying costs to obtain the total material cost of $xxxx.

The assembly cost is estimated to $xxxx, so the manufacturing cost is $xxxx.

With estimated costs of R&D, G&A and Profit, the average selling price can be estimated at $xxxx when using the estimated economic parameters of ZF.
Cameras in ZF S-Cam4 Mono & Tri
CIS and Camera Module Analysis
SP19457 - IMAGING report by Audrey LAHRACH
PHYSICAL ANALYSIS done by Guillaume CHEVALIER
May 2019 – version 1
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<tr>
<td>✓ Cross-Section</td>
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<tr>
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<td>o S-Cam4 Mono Camera</td>
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<td></td>
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<tr>
<td>✓ Camera #1 Cost Estimation</td>
<td></td>
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<tr>
<td>✓ Camera #2 Cross-Section</td>
<td></td>
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<tr>
<td>✓ Camera #2 Cost Estimation</td>
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<tr>
<td>✓ Sensor Die View &amp; Dimensions</td>
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<td>✓ Sensor Delaying &amp; main Blocs</td>
<td></td>
</tr>
<tr>
<td>✓ Sensor Die Process</td>
<td></td>
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<tr>
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<td></td>
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<tr>
<td>✓ Wafer Front-End Cost</td>
<td></td>
</tr>
<tr>
<td>✓ BSI Front-End Cost</td>
<td></td>
</tr>
<tr>
<td>✓ Color Filters &amp; Microlenses FE Cost</td>
<td></td>
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<tr>
<td>✓ Sensor Die Wafer Cost</td>
<td></td>
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<td>o Packaged Component</td>
<td></td>
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<tr>
<td>✓ Packaging Cost</td>
<td></td>
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<td>✓ Component Probe Test &amp; Dicing</td>
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<td>✓ Component Cost</td>
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The reverse costing analysis is conducted in 3 phases:

**Teardown analysis**
- Package is analyzed and measured
- The dies are extracted in order to get overall data: dimensions, main blocks, pad number and pin out, die marking
- Setup of the manufacturing process.

**Costing analysis**
- Setup of the manufacturing environment
- Cost simulation of the process steps

**Selling price analysis**
- Supply chain analysis
- Analysis of the selling price
Camera Module Cross-Section

Cross-section plane #1

Package Cross-section plane #1
The Optical Module is estimated at $xxx.
CIS Package Views & Dimensions

- Package: xxxxx
- Dimensions: xxx x xxx x xxx mm
- Pin Pitch: xxx mm
CIS Package Cross-Section

Package Top View
©2019 by System Plus Consulting
CIS Die Views & Dimensions

- **Die Area:** \( xxxx \text{ mm}^2 \)  
  \((xxxx \times xxxx \text{ mm})\)
- **Pad number:** xx
xxx memory is present on the circuit.
Packaging Process Flow (1/2)
The **Wafer front-end cost** for the CIS circuit is estimated at $\textit{xxx in 2019}.

The largest portion of the manufacturing cost is due to the **Wafer Front-End cost at xx%**.

We estimate a **gross margin of xx%** for the foundry supplier xxxx, which result in a **Wafer price at $\textit{xxxx in xxxx}**. This correspond to the selling price to Omnivision.
The **packaging cost** is estimated at **$xxxx in 2019**.

The largest portion of the manufacturing cost is represented by the **equipment cost at xx%**.

We estimate a **gross margin of xx%** for xxxxx, which result in a **packaging price** at **$xxx in 2019**. This corresponds to the selling price to Omivision.
### Component Cost

<table>
<thead>
<tr>
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<th>Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Wafer Price</td>
<td></td>
</tr>
<tr>
<td>Package Price</td>
<td></td>
</tr>
<tr>
<td>Probe Test Cost</td>
<td></td>
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<tr>
<td>Dicing Cost</td>
<td></td>
</tr>
<tr>
<td><strong>Total Wafer Cost</strong></td>
<td></td>
</tr>
<tr>
<td>Nb of potential dies per wafer</td>
<td></td>
</tr>
<tr>
<td>Nb of good dies per wafer</td>
<td></td>
</tr>
<tr>
<td>Die Cost</td>
<td></td>
</tr>
<tr>
<td>Probe Test &amp; Dicing Cost</td>
<td></td>
</tr>
<tr>
<td>Package Cost</td>
<td></td>
</tr>
<tr>
<td>BE : Yield losses</td>
<td></td>
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<tr>
<td><strong>Component Cost</strong></td>
<td></td>
</tr>
<tr>
<td>Final Test Cost</td>
<td></td>
</tr>
<tr>
<td>BE : Yield losses</td>
<td></td>
</tr>
</tbody>
</table>

By adding the probe test, the Package and the dicing cost, the CIS Wafer cost is estimated at $xxxx in 2019.

The number of good dies per wafer is estimated at xxx in 2019, which results in a die cost at $xxx.

The component cost is estimated at $xxxx in 2018.

- The CIS die represents xx% of the component cost.
- The package assembly represent xx% of the component cost.
- Probe Test, Dicing, Final test and yield losses represent xx% of the component cost.
We estimate that Omnivision realizes a gross margin of xx% on the CIS, which results in a final component price estimated at $xxx.

This corresponds to the selling price for 1M quantity to OEMs.
Related Reports

REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING

IMAGING
• Mobileye EyeQ4 Vision Processor Family
• TRW S-Cam 3 – Forward Automotive Camera for Advanced Driver Assistance Systems
• FLIR Boson – a small, innovative, low power, smart thermal camera core

MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT

IMAGING
• Status of the CMOS Image Sensor Industry 2018
• Artificial Intelligence Computing for Automotive 2019
• LiDAR for Automotive and Industrial Applications 2019
• Radar and Wireless for Automotive: Market and Technology Trends 2019
Currently, automotive manufacturers are integrating more options for security and are making cars safer with Advanced Driver Assistance Systems (ADAS). Automotive cameras therefore have quickly become more common in the last few years and are now an important part of the imaging market.

ZF, one of the largest tier one suppliers of automotive systems, last year released its fourth Generation S-Cam with two solutions, one with a mono camera and the other with a triple camera set-up.

These cameras feature the Omnivision CMOS image sensor, which demonstrates the shift in the procurement strategies of ZF and Intel Mobileye. In fact, the use of the latest Mobileye EyeQ4 vision processor allows new sensors to be used and makes the S-Cam4 one of the smallest and lightest products in its category.

Based on a teardown of the system, these reports detail a complete bill of material and describe the electronics and housing assembling. Moreover, a specific report describes the camera’s manufacturing and packaging processes. They present also a detailed physical analysis of the CMOS image sensor, with a cross-section of the complete camera modules.

These reports also include a comparison with the previous version in the S-Cam series, the S-Cam 3. It estimates the manufacturing cost and selling price for both the mono and tri-camera.

The teardown and the cost analysis of the System On Chip (SOC) is available in the related report “Mobileye EyeQ4 Vision Processor Family”.

**COMPLETE TEARDOWN WITH**

- Detailed photos
- Precise measurements
- Materials analysis
- Complete bill of material
- Component pricing
- Detailed technological and cost analysis of camera and CMOS image sensor
- Physical comparison with ZF S-Cam3
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis in two countries
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RELATED REPORTS

Mobileye EyeQ4 Vision Processor Family
Fourth generation Mobileye vision processor for Advanced Driver Assistance Systems:
EyeQ4-High version for Tri-cam and EyeQ4-Mid version for Mono-cam.
April 2019 - EUR 3,990*

TRW S-Cam 3 – Forward Automotive Camera for Advanced Driver Assistance Systems
Third and latest version of TRW’s best-selling S-Cam series forward camera.
April 2017 - EUR 2,990*

FLIR Boson – a small, innovative, low power, smart thermal camera core
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September 2017- EUR 3,490*
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Card Verification Value: |__|__|__|

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• In EUR
  Bank code : 30056 - Branch code : 00955 - Account : 0955000323
  IBAN: FR76 3005 6009 5509 5500 0323 439
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• RF: FEM - Duplexer
• Systems: Automotive - Consumer - Energy - Telecom
TERMS AND CONDITIONS OF SALES

1. Scope

1.1 The Contracting Parties undertake to observe the following general conditions and agree with the Seller: Any ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS in ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY DELETED TO THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 The parties are bound and enforceable between the Contracting Parties after clear and non-equivalent consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions "I hereby accept Yole’s Terms and Conditions of Sale". This results in acceptance by the Buyer.

1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7] days from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

2. Mailing of the Products

2.1 Within [30] days from the order date the Seller shall make available to the Buyer:

- within [2] month from the order for Products already released;

- within a reasonable time for Products ordered prior to their effective delivery.

In case of delay, the Seller shall be liable for any delay in respect of article 2.2 above, and including taxes where a new event or access to new contradictory information would require for the actual extra time to compute or company data to be collected to enable the Seller to deliver the Product.

2.3 The mailing of the Product will only occur upon payment by the Buyer, in accordance with the conditions contained in articles 3.1 and 3.3. The Seller reserves the right to require payment in advance for Products, the Buyer will be made aware of this before delivery. The delivery will not occur until the payment is received in full.

2.4 Payment is due by the Buyer to the Seller within [30] days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to suspend the contract in accordance with the order conditions on merits or matters, or even to demand a remittance of the purchase price due. The replacement is guaranteed for a maximum of two months starting from the date of the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below. The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are no longer binding. A delay is always subject to the Buyer. Within [8] months from the date of the订购 Product, for the Buyer to be entitled to ask for a reimbursement of its first down payment to the Seller, the Buyer shall be entitled to do so in accordance with the order conditions of the Buyer’s own contractual rights.

2.5 The Seller on the stage in progress, and to take legal action for damages.

3. Liabilities

3.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretation he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

3.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement.

3.3 In no event shall the Seller be liable for:

- damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of use or inability to use the Seller’s website or the Products, or any information provided on the website, or in the Products;

- the Seller’s inability to modify or correct the information or other inaccuracies in the Product or interpretations thereof.

4.4 The information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 The Seller is not liable for the Product’s skills may, upon prior notice to the Buyer from time to time be modified or by substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are no longer binding. A delay is always subject to the Buyer to the extent that it is not due to the Seller’s own contractual rights.

4.8 The Seller shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

4.9 The Buyer shall define within the time frame of its company for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for the selection of the recipients of the information.

5. In the event of termination of the contract, or of misconduct, the Seller will have the right to the Buyer to stage in progress, and to take legal action for damages.

5.1 The Buyer must notify the Seller in writing, orders shall be deemed to have been accepted.

6.2 The Buyer agrees not to disclose, copy, redistribute, resell or publish the Product, or any part of it to any other party other than employees of the Company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Products for purposes such as:

- Information storage and retrieval systems;

- Recordings and re-transmissions over any network (including any local area network);

- Use in any timesharing, service bureau, bulletin board or similar arrangement or public display;

- Post any Product to any other online service (including bulletin boards or the Internet);

- Licensing, leasing, selling, offering for sale or assigning the Product.

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. The Buyer shall also be responsible for the Seller for any other direct or indirect consequences of the Buyer’s breach.

7.2 In the event of breach by one Party under these conditions or the non-breaching Party may be entitled to recover the Product by recorded delivery upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer. All the provisions of these Terms and Conditions shall be binding on the Buyer upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. Governing law and jurisdiction

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (or orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.

10. French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.
Business Models Fields of Expertise

- Custom Analyses
  (>130 analyses per year)

- Reports
  (>60 reports per year)

- Costing Tools

- Trainings