

Optimizing Semiconductor Manufacturing with MBSE

By Chris Howard

Presented by Steven Dam

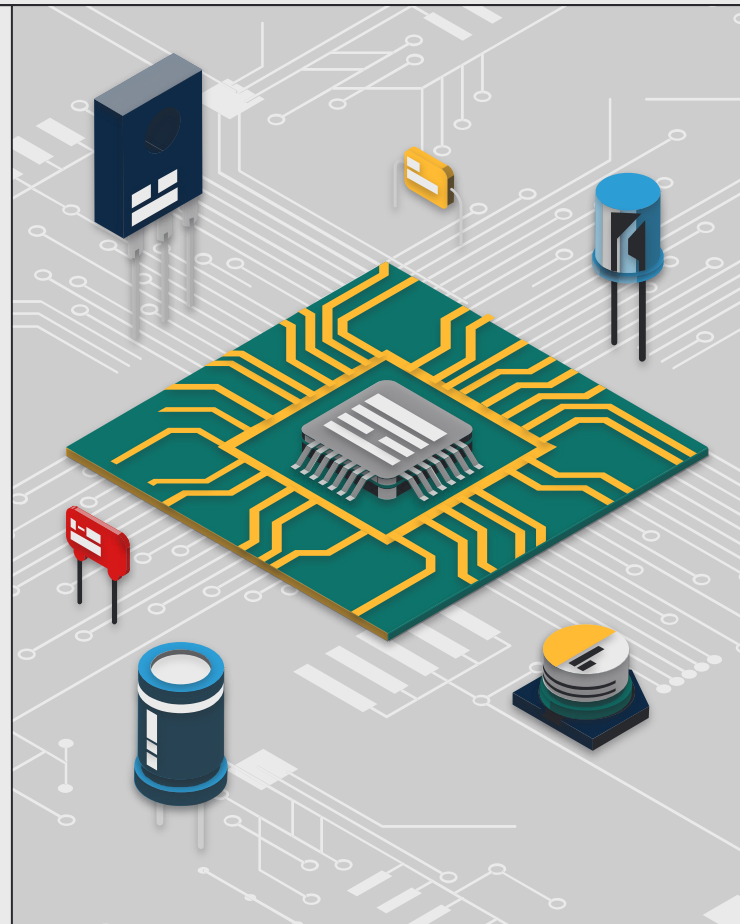


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Different in operations before and after the project.



Author & Presenter



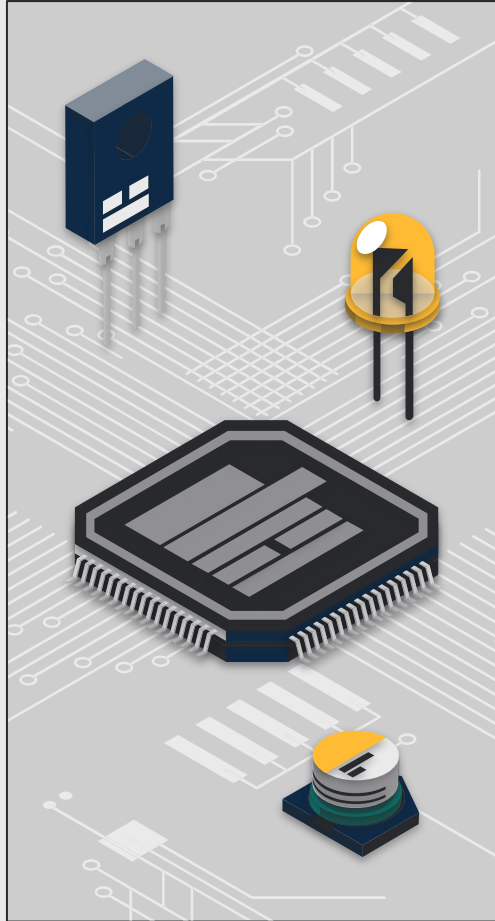
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01

Introduction



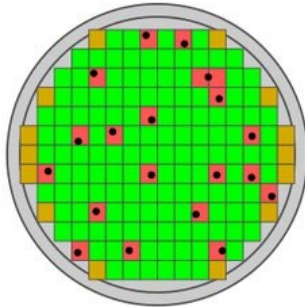
Chip Manufacturing Yield - What is it?

$$Y = \frac{N_{\text{good}}}{N_{\text{total}}}$$

Where,

- N_{good} - number of working dies per wafer
- N_{total} - number of dies per wafer

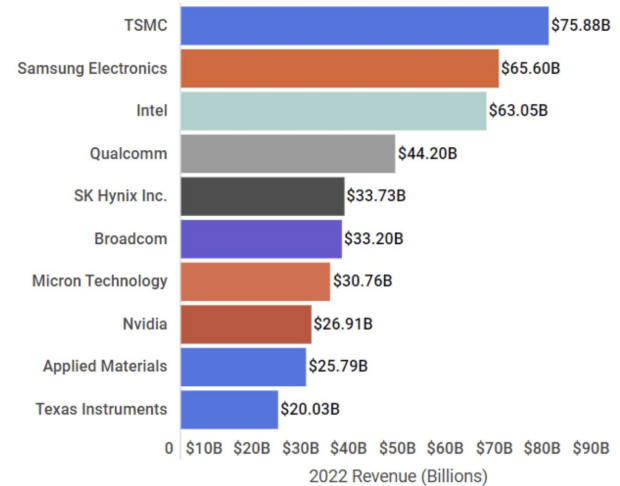
For example, consider a process with a $D_0 = 0.5/\text{cm}^2$, for dies the size of 360 mm^2 .

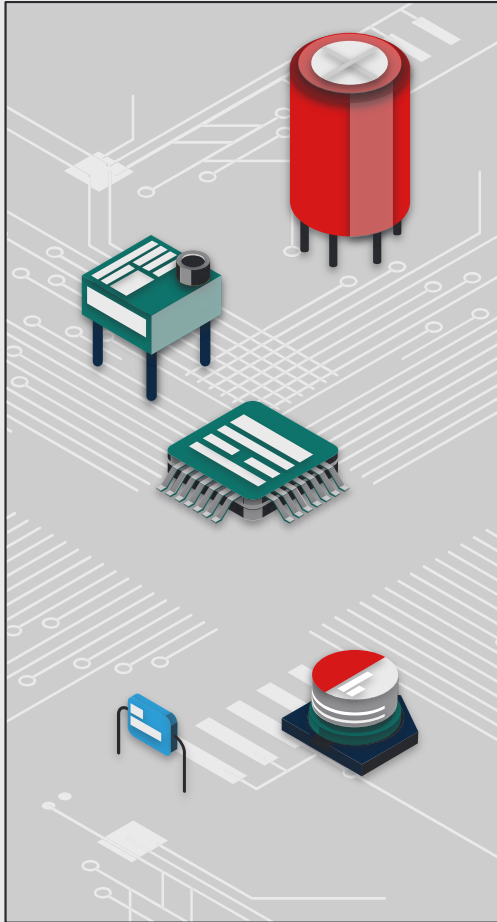


- - defect
- - defective die
- - good die
- - partial edge die

There are 150 dies per wafer and around 24 defective dies per wafer, therefore the yield is $\frac{126}{150} = 84\%$.

LARGEST SEMICONDUCTOR COMPANIES IN THE WORLD





Key Findings

- TSMC (Taiwan Semiconductor Manufacturing Company) has best target model.
- Revenue Impact: Higher Yield Rates correlate to significant revenue boosts.
- Cost Reduction: Lower loss can result in price-per-unit manufacturing to drop by 20%.
- Efficiency: If cost per unit is reduced, overall efficiency increases, as less material is wasted.

02

Project Scope



Improvement Capabilities

Safety

Improvements

Despite increasing production time, safety of workers takes priority.

Product Testing

Through rigorous testing, the products rating can be verified.

01

02

03

04

Supply Chain

With stronger supply lines, the lab can remain operational at all times.

Manufacturing

Process

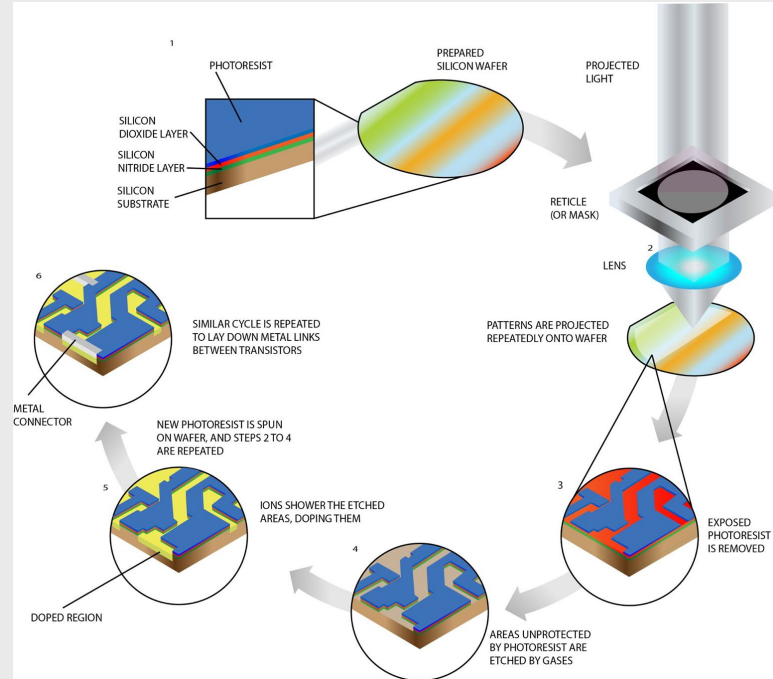
Improving manufacturing methodology and adding more testing can increase yield.



Manufacturing Process - High Level

Let's get a quick visual of the chip manufacturing process.

Keep in mind that this is extremely high level, with much information cut.



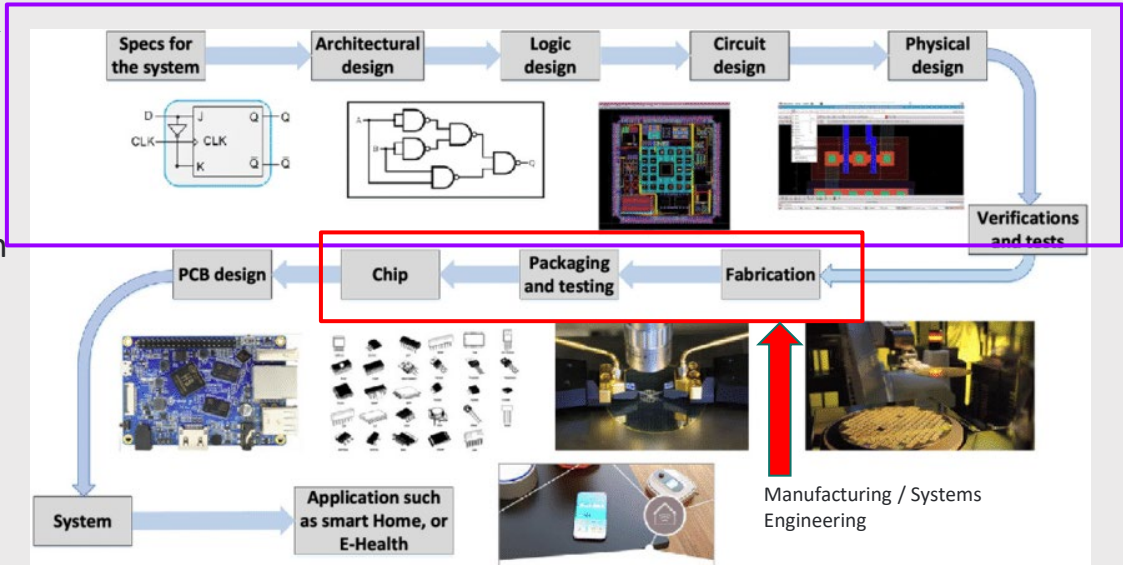
From gallagherseals.com

Manufacturing Process - Use Cases

Electrical & Computer Engineering



High level overview of chip design process to use cases.



From researchgate.net

03

Implementation



MBSE Methods



Diagrams

Diagrams are used in order to model actions, which can consume time or resources previously allocated.



Test Cases

Test cases can be directly linked to requirements or actions to validate them.



Requirements

Similar to most systems engineering, requirements are paramount and can also be modeled in MBSE.

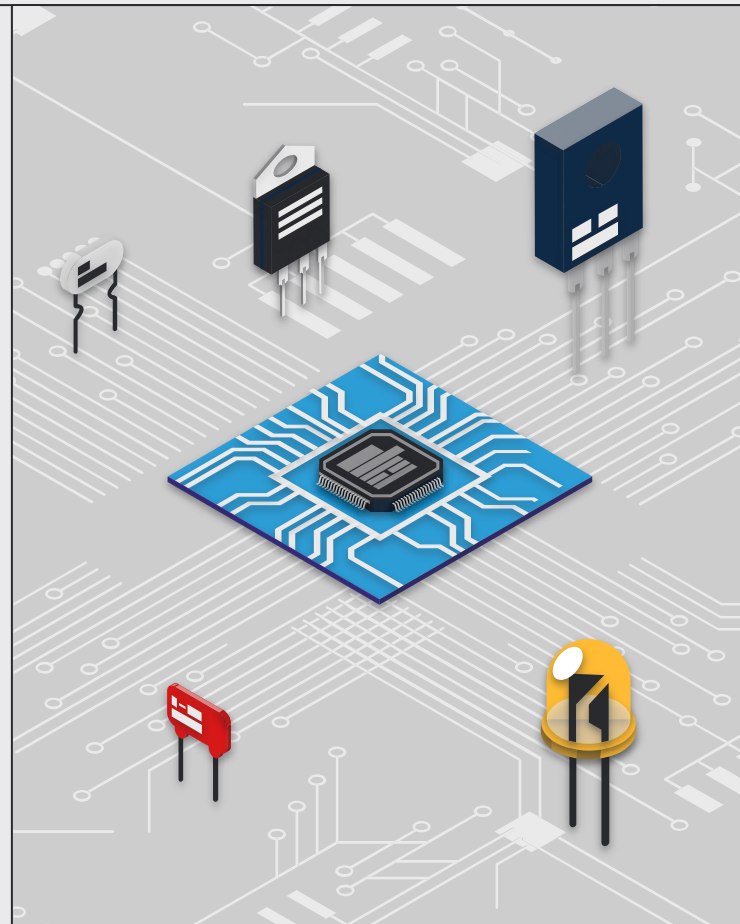


Management Overview

Gives an overview of the current progress of the project, allowing management to stay in tune with the status.



Diagrams

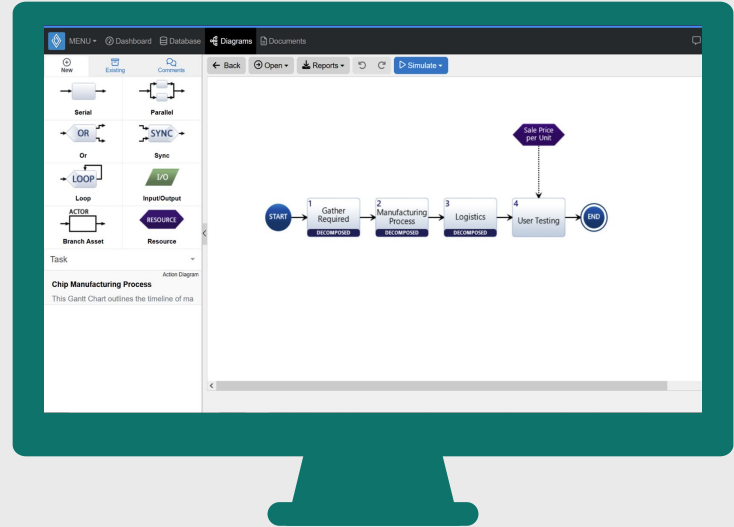


Action Diagram

By creating actions with specified lengths, resource consumption values, and ID's, specific actions and their impact on the system can be tracked.

Overall, diagrams allow stakeholders outside the project have a high level idea of the process of activities.

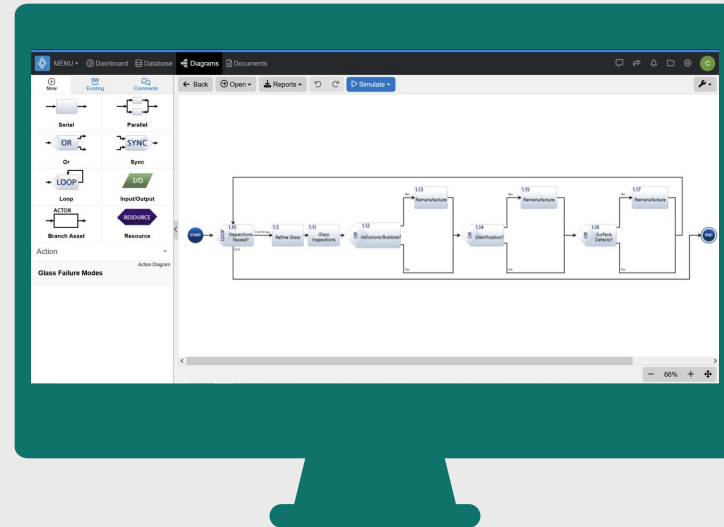
Simulations are also an option to show the projected result of a project.



Current Operation

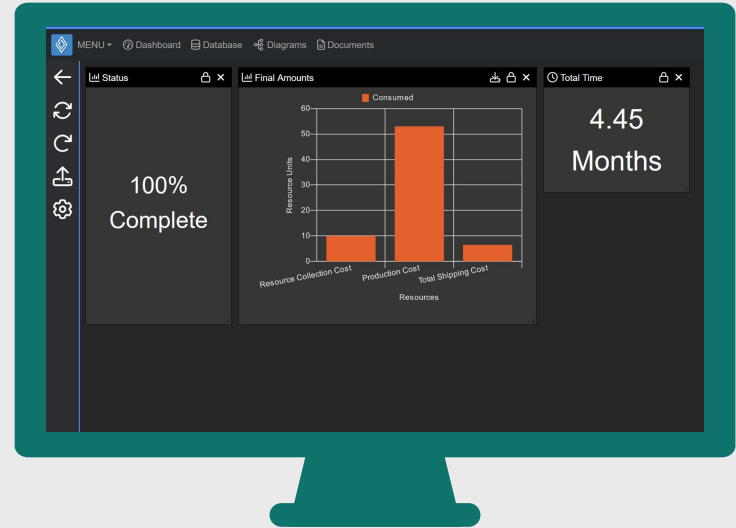
Currently, using fail conditions at given percentage values according to historical data, we can estimate the chance of processes being repeated.

This will result in an increased amount of time and resources spent to manufacture the chip.

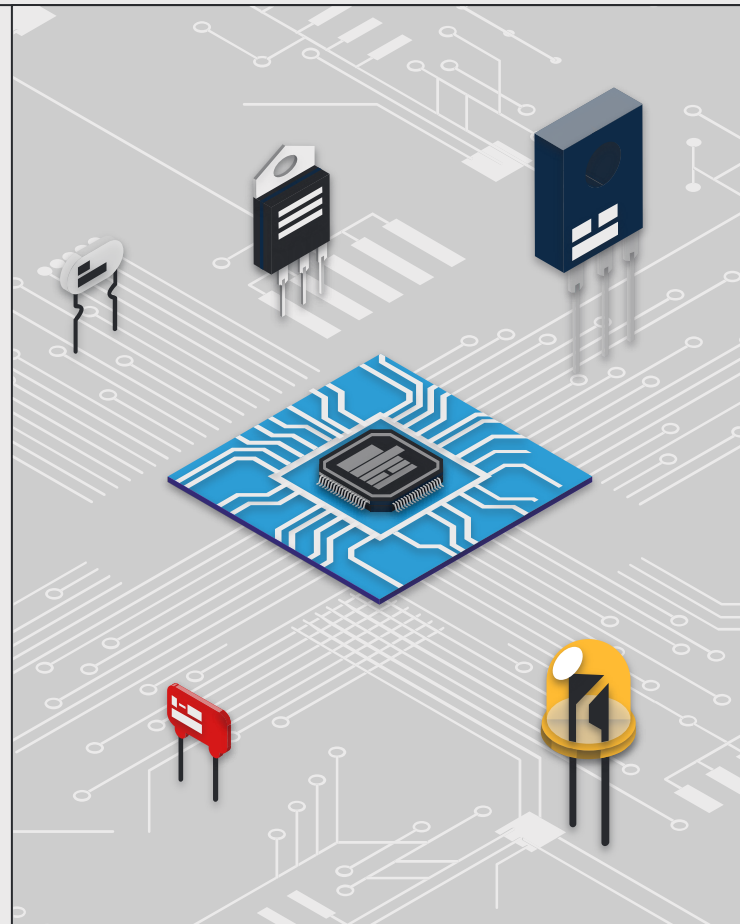


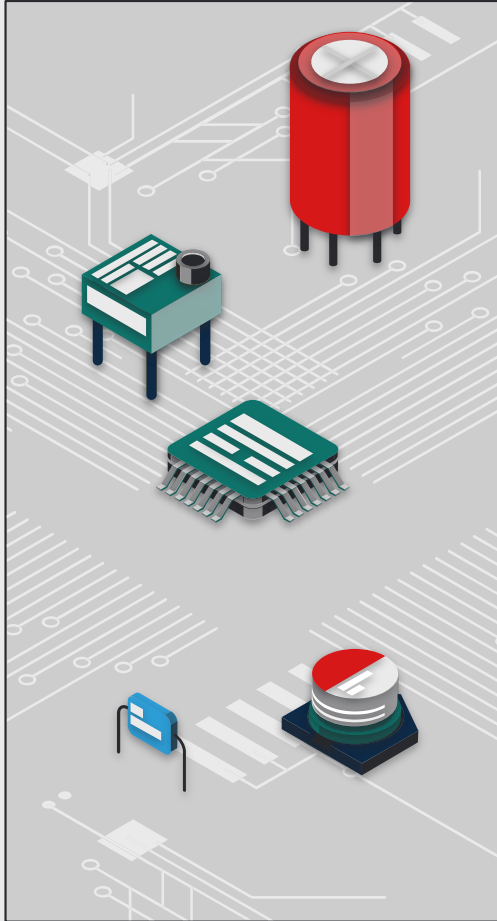
Current Operation

Current Simulation Data:
 Time: 4.45 months
 Resource Collection Cost: 10
 Production Cost: 53
 Shipping Cost: 7
 Total: 70



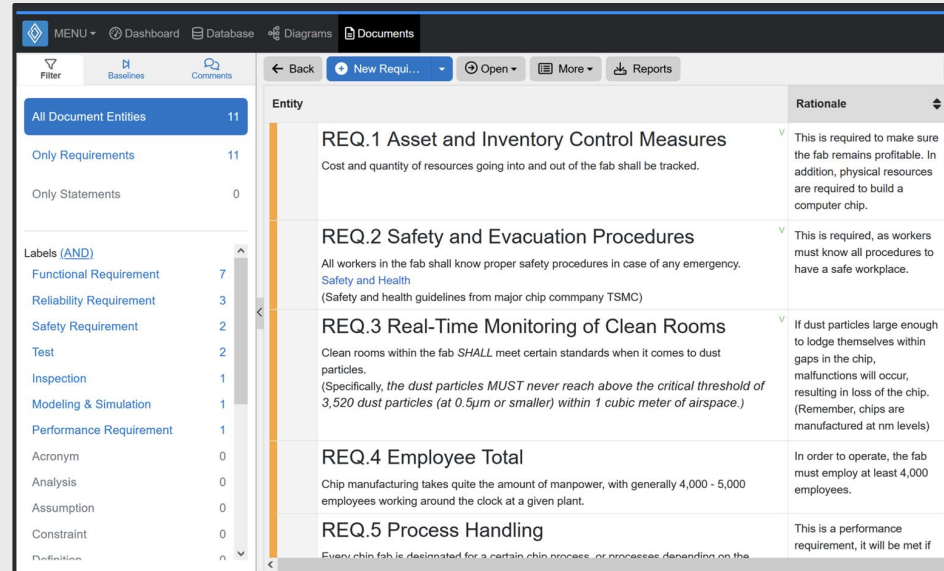
Requirements





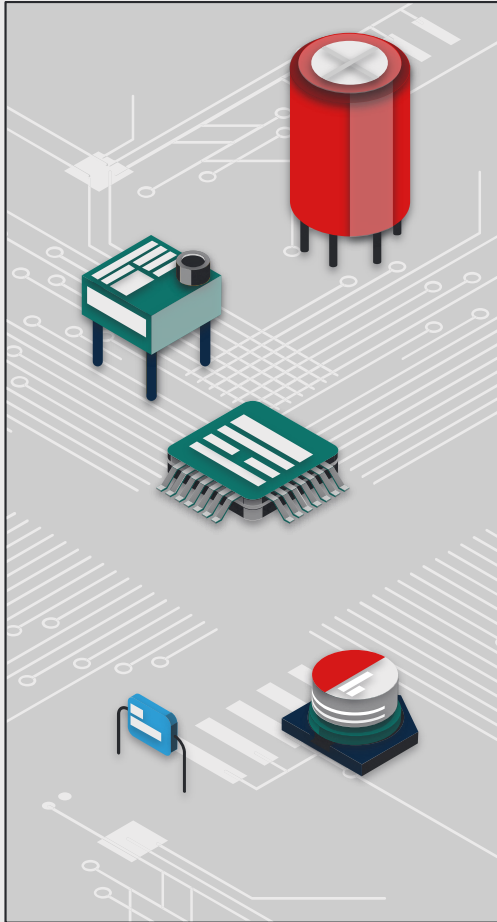
Requirement Usage

- Following the “V-Model” we initially declare requirements
- Clearly defines demands of the project



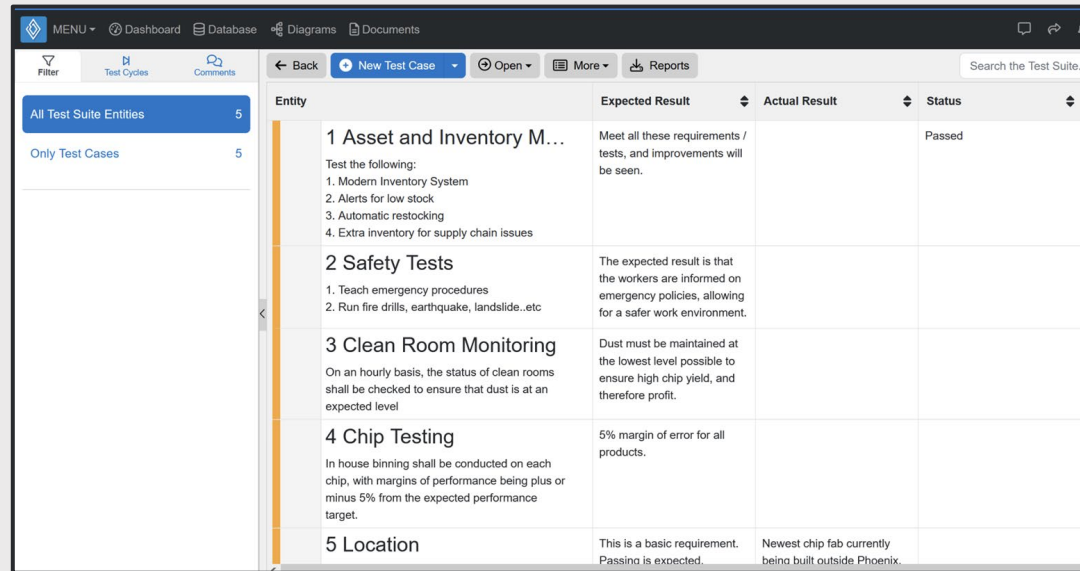
The screenshot shows a software interface with a menu bar (MENU, Dashboard, Database, Diagrams, Documents) and a toolbar (Back, New Requi..., Open, More, Reports). A left sidebar contains a 'Filter' section with a tree view of document entities and labels. The main area displays a table of requirements with columns for 'Entity' and 'Rationale'.

Entity	Rationale
REQ.1 Asset and Inventory Control Measures Cost and quantity of resources going into and out of the fab shall be tracked.	This is required to make sure the fab remains profitable. In addition, physical resources are required to build a computer chip.
REQ.2 Safety and Evacuation Procedures All workers in the fab shall know proper safety procedures in case of any emergency. Safety and Health (Safety and health guidelines from major chip company TSMC)	This is required, as workers must know all procedures to have a safe workplace.
REQ.3 Real-Time Monitoring of Clean Rooms Clean rooms within the fab <i>SHALL</i> meet certain standards when it comes to dust particles. (Specifically, <i>the dust particles MUST never reach above the critical threshold of 3,520 dust particles (at 0.5µm or smaller) within 1 cubic meter of airspace.</i>)	If dust particles large enough to lodge themselves within gaps in the chip, malfunctions will occur, resulting in loss of the chip. (Remember, chips are manufactured at nm levels)
REQ.4 Employee Total Chip manufacturing takes quite the amount of manpower, with generally 4,000 - 5,000 employees working around the clock at a given plant.	In order to operate, the fab must employ at least 4,000 employees.
REQ.5 Process Handling Every chip fab is designated for a certain chip process, or processes depending on the	This is a performance requirement, it will be met if

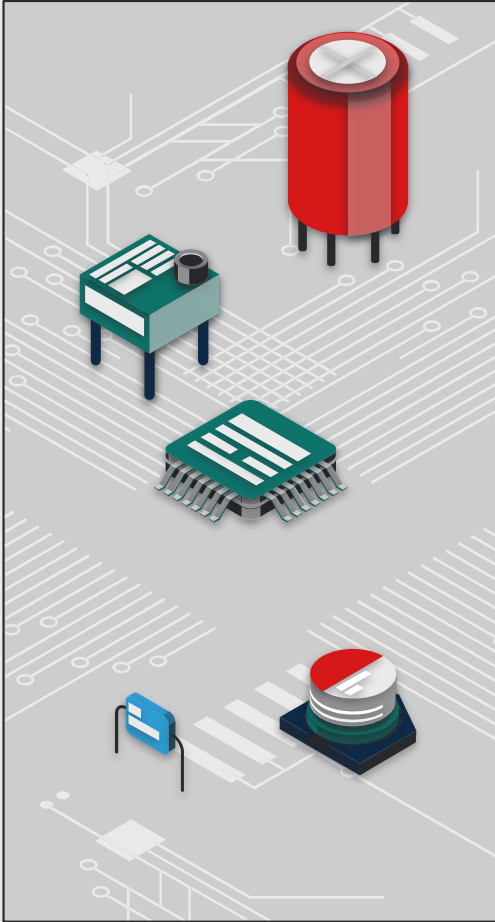


Test Cases

- Test Cases verify requirements
- Mandatory to a successful system



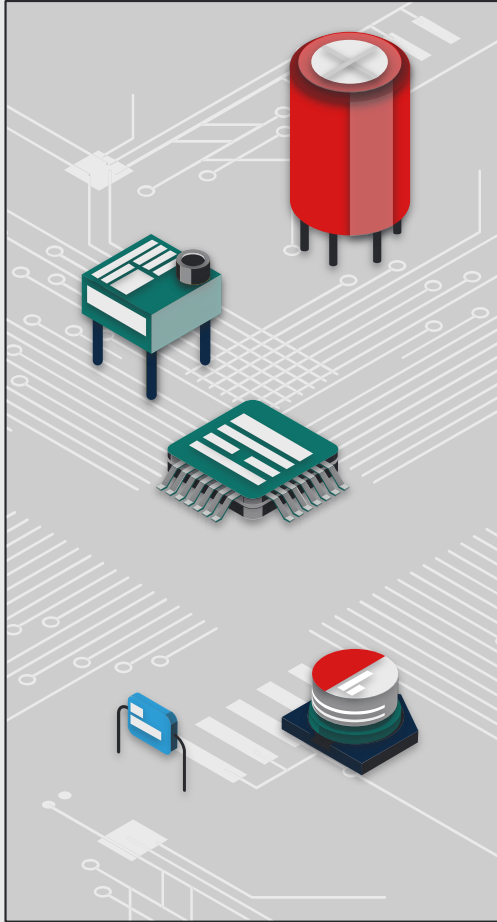
Entity	Expected Result	Actual Result	Status
1 Asset and Inventory M... Test the following: 1. Modern Inventory System 2. Alerts for low stock 3. Automatic restocking 4. Extra inventory for supply chain issues	Meet all these requirements / tests, and improvements will be seen.		Passed
2 Safety Tests 1. Teach emergency procedures 2. Run fire drills, earthquake, landslide...etc	The expected result is that the workers are informed on emergency policies, allowing for a safer work environment.		
3 Clean Room Monitoring On an hourly basis, the status of clean rooms shall be checked to ensure that dust is at an expected level	Dust must be maintained at the lowest level possible to ensure high chip yield, and therefore profit.		
4 Chip Testing In house binning shall be conducted on each chip, with margins of performance being plus or minus 5% from the expected performance target.	5% margin of error for all products.		
5 Location	This is a basic requirement. Passing is expected.	Newest chip fab currently being built outside Phoenix.	



Traceability Matrix

- Allows us to have a clear visual of the requirements being verified by tests.

	1 Asset and Inventory Mana...	2 Safety Tests	3 Clean Room Monitoring	4 Chip Testing	5 Location
MAIN Computer Chip Fab Requirem...					
REQ.1 Asset and Inventory Control ...	X				
REQ.2 Safety and Evacuation Proc...		X			
REQ.3 Real-Time Monitoring of Cle...			X		
REQ.4 Employee Total					
REQ.5 Process Handling					
REQ.5.1 Process Handling Informat...					
REQ.6 Chip Testing				X	
REQ.6.1 Methodology					
REQ.7 Shipping					
REQ.8 Location					X
REQ.8.1 Construction Quality					



Management View

- Allows project stakeholders to view overall progress of project in a high level overview.

SPEC Innovations / Chip Manufacturing Project

Project Management Dashboard

→ Kanban Boards Dashboard → Gantt Charts Dashboard [Add Widget](#)

May 2024

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5 Cinco de Mayo	6	7	8	9	10	11
12 Mother's Day	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27 Memorial Day	28	29	30	31	

Upcoming Dates

In stores

Start Date: *June 20th, 2024, 12:00 AM"
Last Modified: *January 4th, 2024, 4:02 PM"

1 Gather Required Resour...

Due Date: *April 2nd, 2026, 12:00 AM"
Completed: 0%
Last Modified: *May 28th, 2024, 12:47 PM"

2 Manufacturing Process

Due Date: *July 9th, 2028, 12:00 AM"
Completed: 0%
Last Modified: *May 28th, 2024, 12:46 PM"

3 Logistics

Due Date: *August 15th, 2028, 12:00 AM"
Completed: 0%

No Kanban Boards found. Get started by navigating to [Charts Dashboard](#) and creating a new Kanban Board by clicking 'New Chart'.

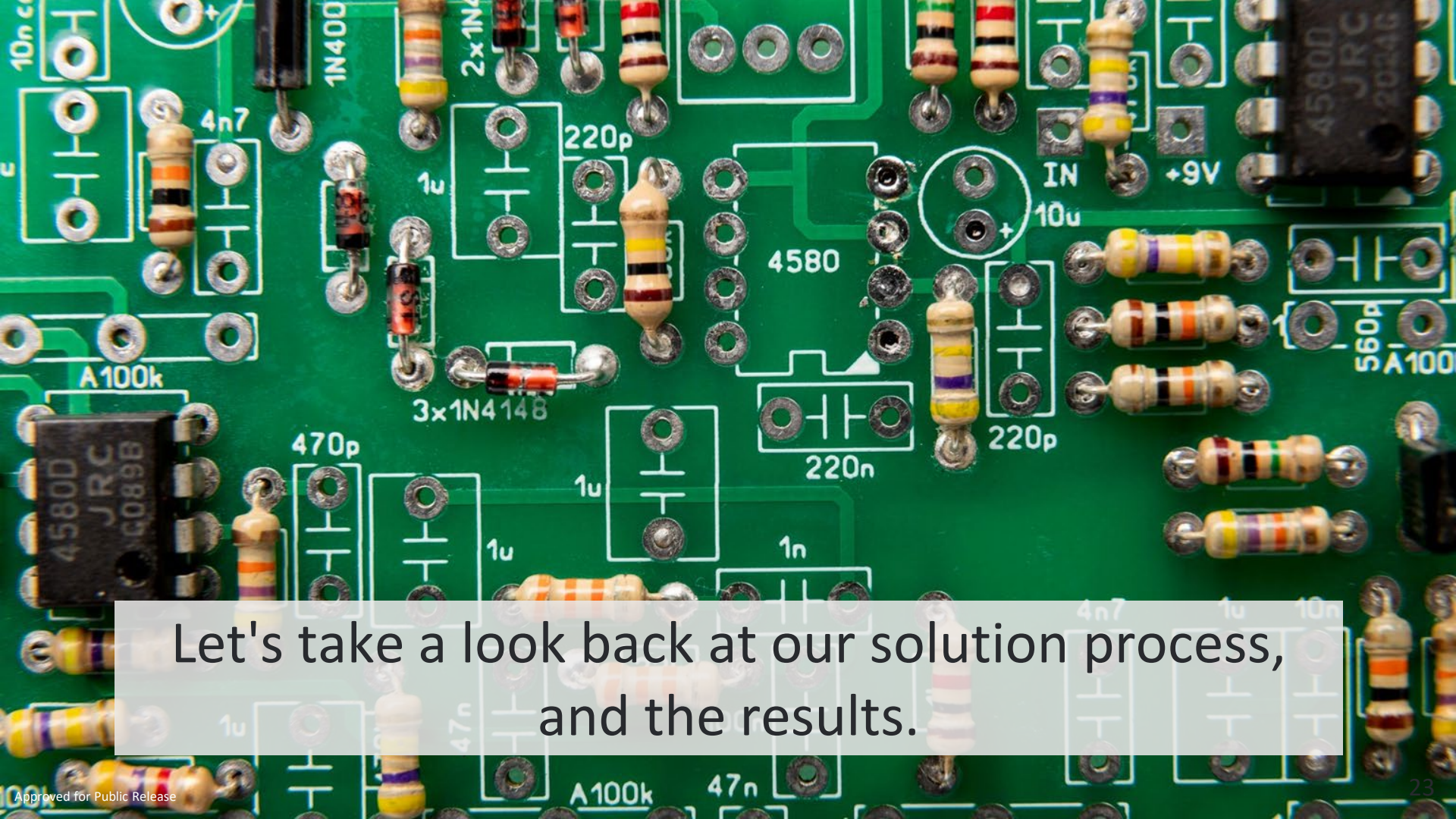
Hierarchy Diagram

No Kanban Boards found. Get started by navigating to [Charts Dashboard](#) and creating a new Kanban Board by clicking 'New Chart'.

04

Summary & Conclusion





Let's take a look back at our solution process,
and the results.

Solution Process

New plans for the project must be defined.

Management



Thorough test cases to validate requirements.

Test Cases



Requirements



Results

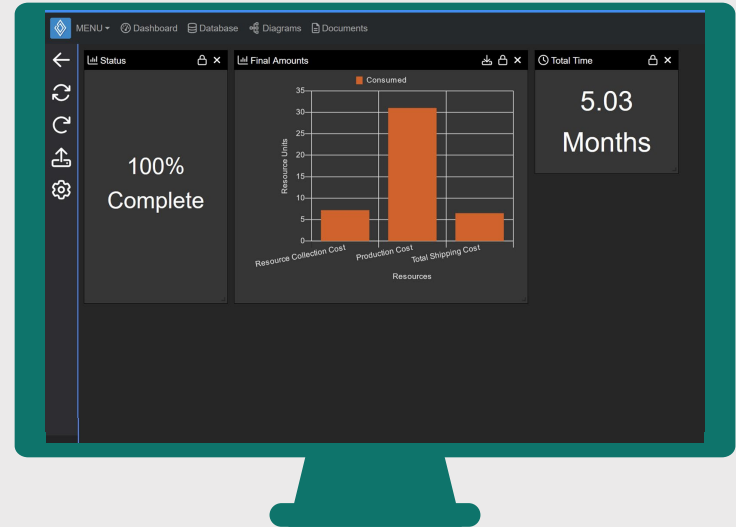
Specific requirements and standards must be created.

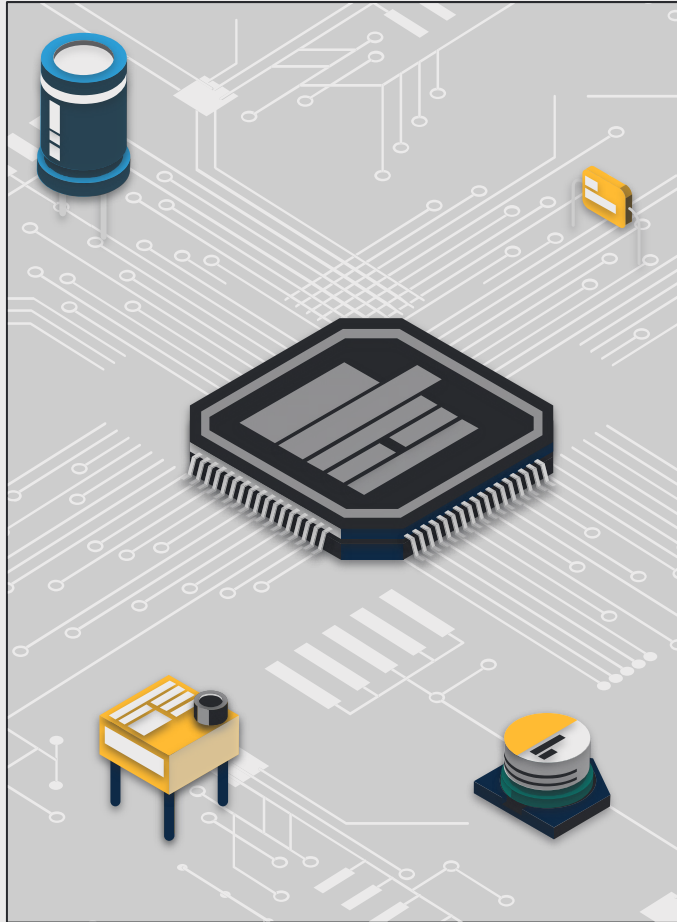
System implemented fully.

New Operations

New Simulation Data:
 Time: 5.03 months
 Resource Collection Cost: 7.20
 Production Cost: 31
 Shipping Cost: 7
 Total: 45.20

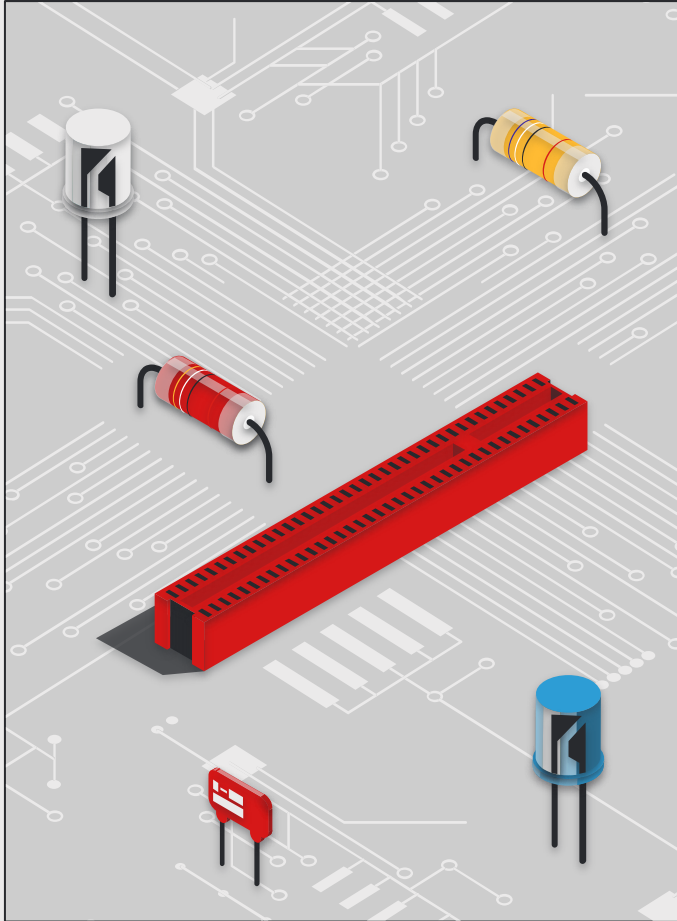
35% reduction in production cost / 35%
 improvement in yield.
 10% increase in production time with extra tests





Takeaway:

To sum up, MBSE can be employed in order to provide organized testing and resource tracking in order to improve chip yield, which leads to higher profit and relevance in the industry,



Questions?