

### (1) Introduction

Based on the historical study of automated warehouse systems by KIT (Poster No. 34) a systematic methodology is developed to model these systems in early development phases, focusing on identifying functional areas independent of specific technologies or layouts. The aim is to establish a comprehensive framework that organizes qualitative and quantitative parameters systematically, providing a basis for a generic standard for performance-based evaluation.

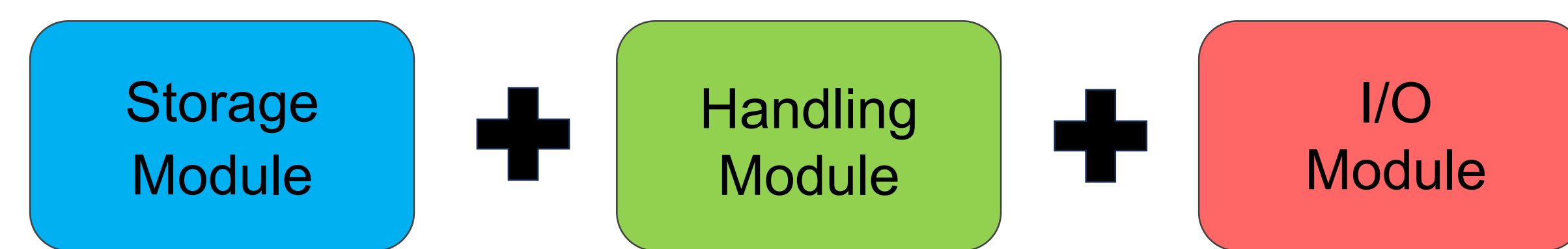
#### Research questions:

- How can a storage system be meaningfully divided into functional areas regardless of technologies and varying layouts?
- Which parameters are required to qualitatively describe an automated storage system?
- How can relevant parameters be systematically organized in a morphological structure?

### (2) Systematic framework

Developing a modular framework consisting of storage, handling, and I/O modules enables the systematic representation of warehouse systems independently of specific technologies or layouts. This approach allows for independent modeling of each module while maintaining overall consistency through defined coupling conditions, forming the basis for subsequent quantitative analysis.

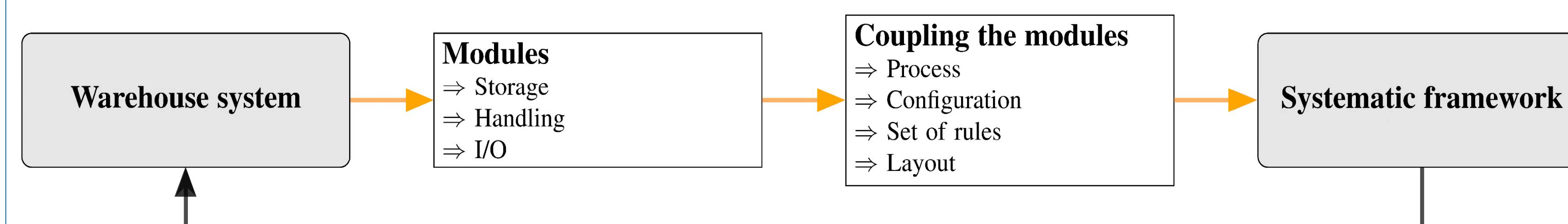
#### Modules:



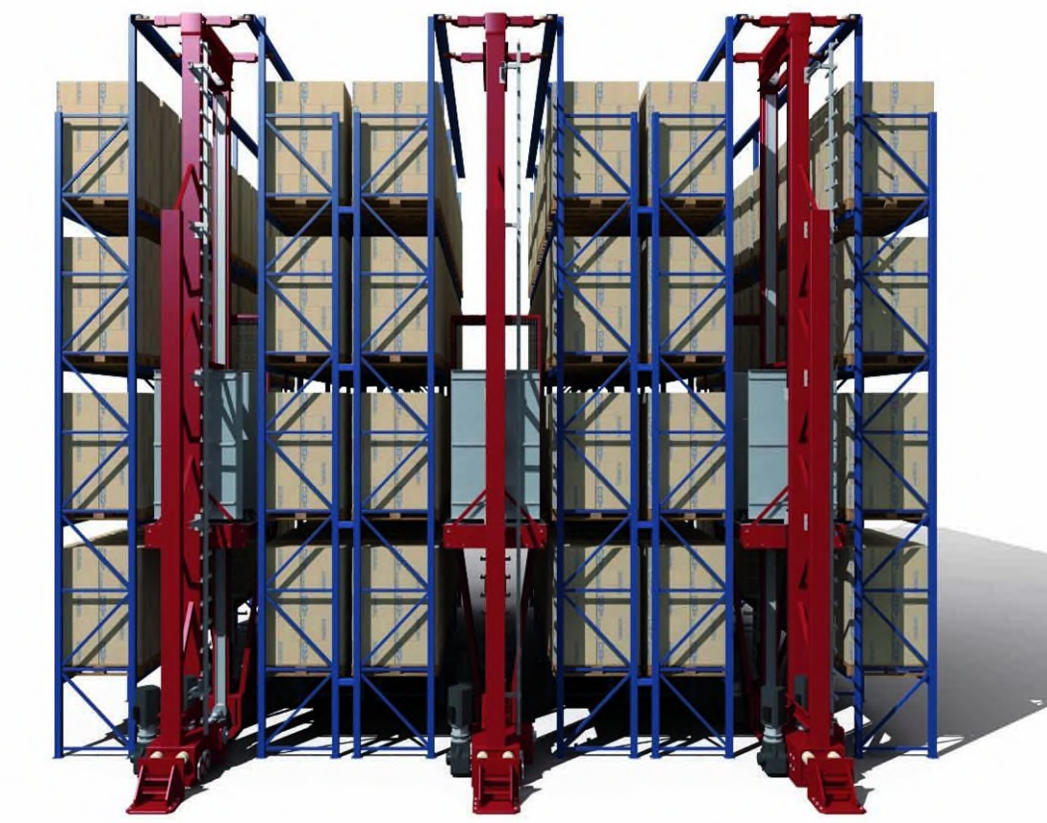
#### The use of modules has the following advantages:

- Independency of technologies and layouts.
- Flexible modifications through modular structure
- Expandability for future system adaptations
- Foundation for automated throughput calculation

#### The process therefore:



### (3) Integration into the framework

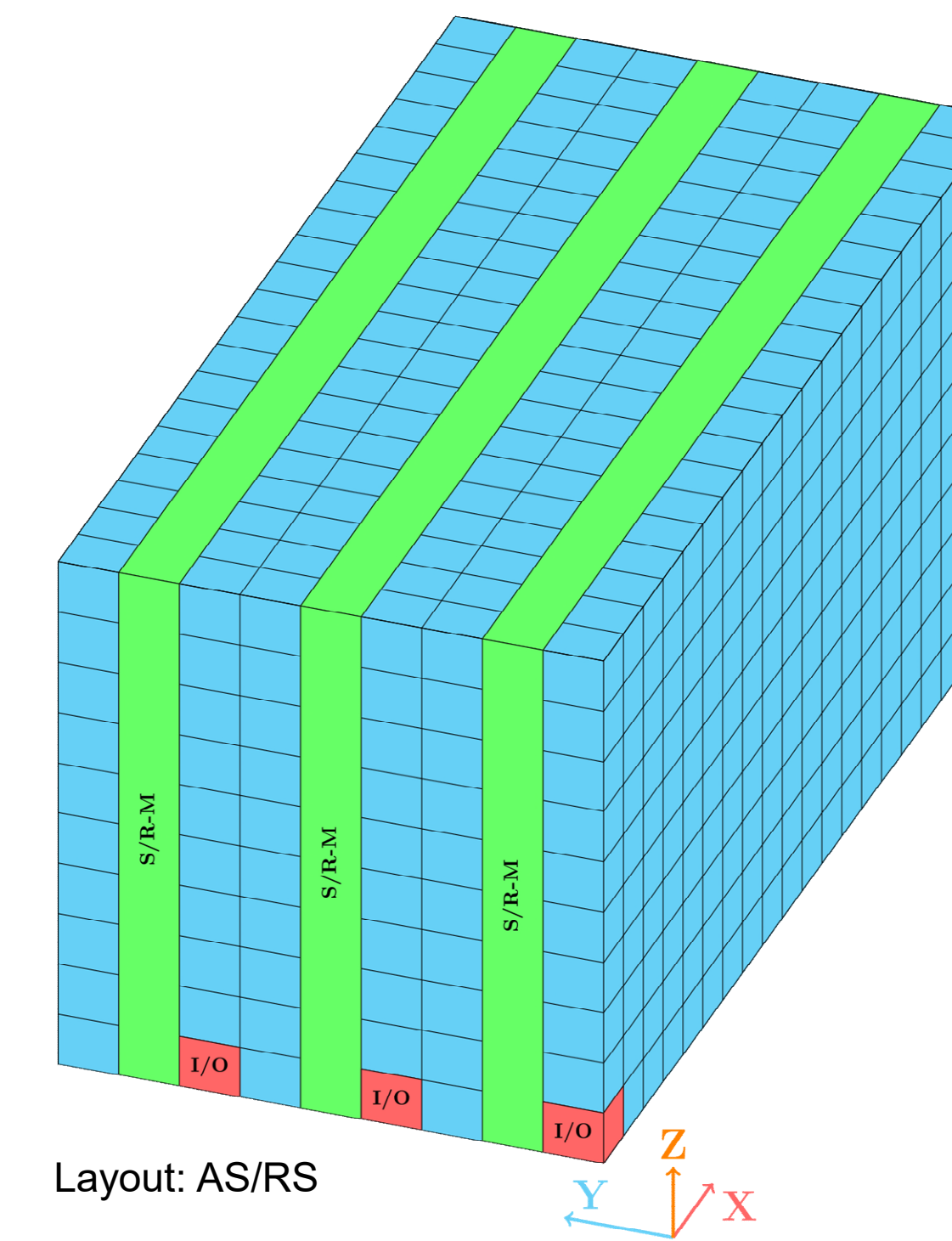


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Systematic framework

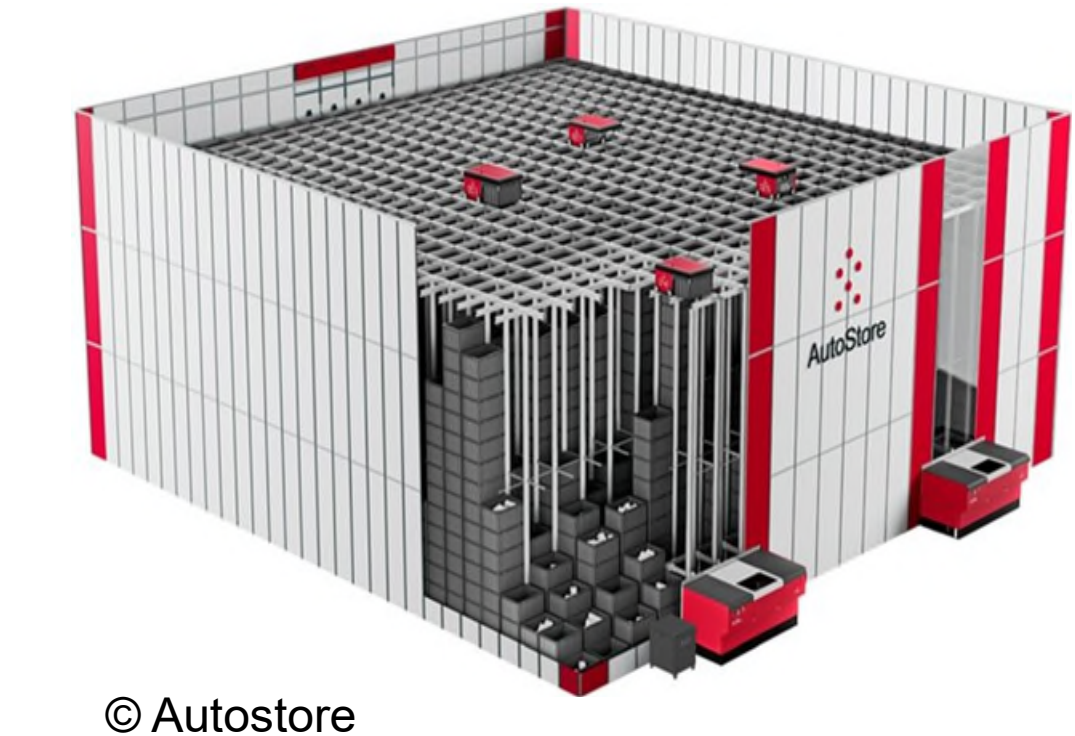
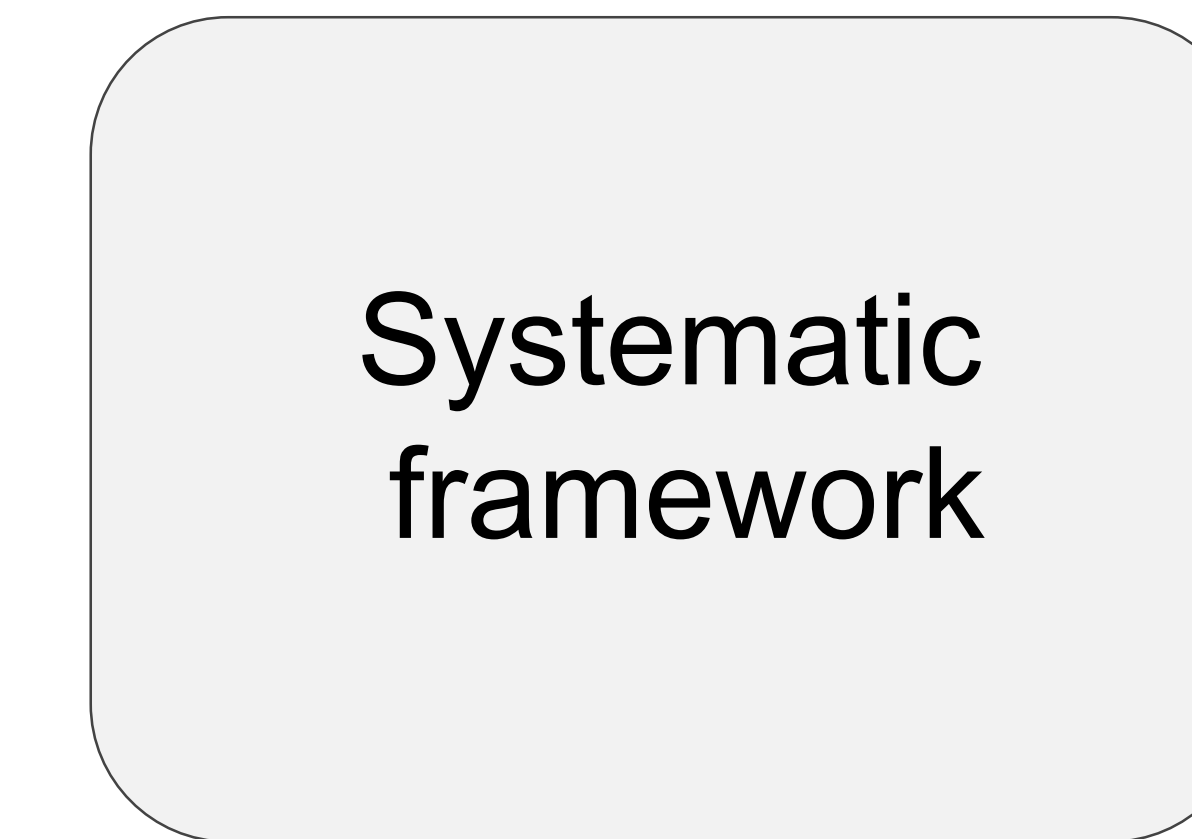
Storage Module	Handling Module	I/O Module
Storage form: Rectangle prisma	Type: S/R-M	Size: 1x1x1
Size: 20x9x10	Size: 20x1x10	Location: Fixed
Storage strategy: Random	Location: Fixed	Mobility / Movement: Fixed
Storage and Retrieval policy: None	Mobility / Movement: X,Y,Z	Movement sections: 0
Storage location: Uniform	Movement sections: 2	Mobility in Movement section: Fixed
Storage location size: 1x1x1	Mobility in Movement section: [XZ;Y]	Handling direction: Y
Storage unit: Uniform	Storage direction: Y	Capacity: ∞
Storage unit size: 1x1x1	Retrieval direction: Y	Handling: Storage Unit
Storage unit capacity: 1	Storage depth: 1	
Storage direction: Y	Retrieval depth: 1	
Retrieval direction: Y	Capacity: 1	
Mobility: Fixed	Relocation strategy: None	
Filling degree: 0.8	Return Relocations: No	
	Command cycle: SCC	
	Order fulfillment: FCFS	
	Handling: Storage Unit	



Layout: AS/RS

Process & Configuration & Set of rules			
Process:			
Storage process:	I/O-Module	Handling module (S/R-M)	Storage Module
Retrieval process:	Storage Module	Handling module (S/R-M)	I/O-Module
Configuration:			
Storage Module: 1		Quantity:	
Handling module (S/R-M): 3		I/O-Module: 3	
Set of rules:			
Storage Module: Not necessary			
Handling module (S/R-M): Not necessary			
I/O-Module: Right-hand side of the S/R-M at the beginning of the rack in the lowest storage location.			

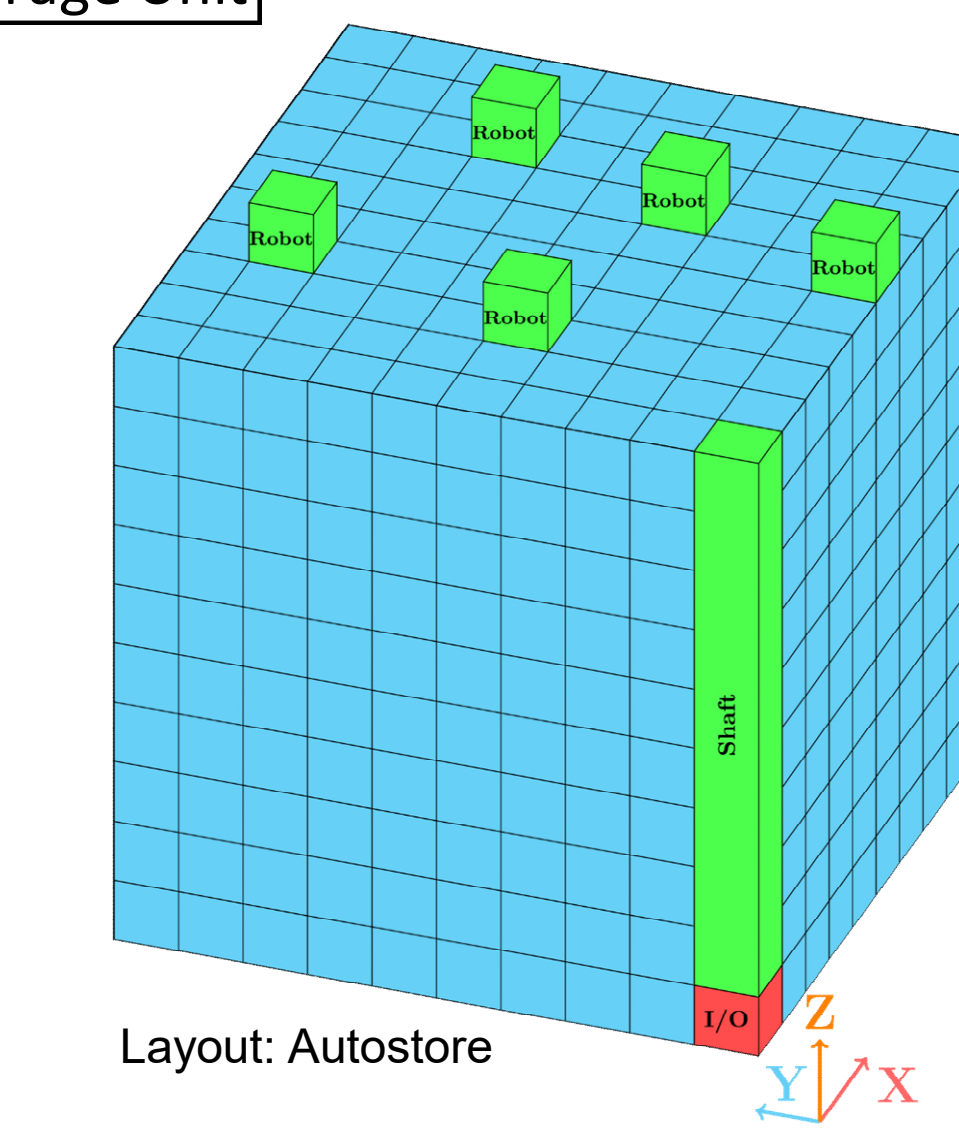
### (4) Extraction from the framework



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Storage Module	Handling Module	Handling Module	I/O Module
Storage form: Cube	Type: Robot	Type: Shaft	Size: 1x1x1
Size: 10x10x10	Size: 1x1x1	Size: 1x1x9	Location: Fixed
Storage strategy: Random	Location: Mobil	Location: Fixed	Mobility / Movement: Fixed
Storage and Retrieval policy: LIFO	Mobility / Movement: X,Y,Z	Mobility / Movement: Z	Movement sections: 0
Storage location: Uniform	Movement sections: 2	Mobility in Movement section: [Z]	Mobility in Movement: Fixed
Storage location size: 1x1x1	Mobility in Movement section: [X,Y;Z]	Storage direction: Z	Handling: Z
Storage unit: Uniform	Storage direction: Z	Retrieval direction: Z	Capacity: ∞
Storage unit size: 1x1x1	Retrieval direction: Z	Storage depth: 0	Handling: Storage Unit
Storage unit capacity: 1	Storage depth: Z	Retrieval depth: 0	
Storage direction: Z	Retrieval depth: Z	Capacity: 1	
Retrieval direction: Z	Capacity: 1	Relocation strategy: Nearest neighbour	
Mobility: Fixed	Relocation strategy: Nearest neighbour	Return Relocations: Yes	
Filling degree: 0.8	Return Relocations: Yes	Return Relocations: No	
	Command cycle: SCC	Command cycle: SCC	
	Order fulfillment: FCFS	Order fulfillment: None	
	Handling: Storage Unit	Handling: Storage Unit	

Process & Configuration & Set of rules				
Process:				
Storage process:	I/O-Module	Handling module (Shaft)	Handling module (Robot)	Storage Module
Retrieval process:	Storage Module	Handling module (Robot)	Handling module (Shaft)	I/O-Module
Configuration:				
Storage Module: 1		Quantity:		
Handling module (Robot): 5		Set of rules:		
Handling module (Shaft): 1		Storage Module: Not necessary		
I/O-Module: 1		Handling module (Robot): Driving area on top level		
		Handling module (Shaft): Above I/O module		
		I/O-Module: Location at 0x0x0		



Layout: Autostore

### (5) Outlook

The modular framework enables consistent qualitative system descriptions and targeted adjustments without disrupting overall structure. Future work will focus on quantitative evaluation and automated throughput calculation.