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Systematisk ferdigstilling
FMI-veilederen Ver. 1.0
Funksjon Modenhets Index
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Systematic Completion
The FMI Guide ver. 1.0
Function Maturity Index

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1. Terms and Definitions

Term / Abbreviation	Definition
FMI	Function Maturity Index. The index provides a value to be able to understand the status of the individual systems throughout the course of the project. It describes the degree of maturity of the systems in the project using unified numerical codes.
BIM	Building Information Modelling. The use of a shared digital representation of a building to facilitate design, construction and operational processes so that a reliable basis for decisions can be formed.
MMI	Model Maturity Index. Describes the degree of maturity of the objects in construction models using unified numerical codes. MMI is primarily a methodology for communication and management processes in the building's project phase and operational phase.
Table Test	A theoretical test which is carried out before detailed design and construction are completed. The basis are the system's functional descriptions, the system diagrams, the automation tables and the test procedures. The tablet test is also part of the operating personnel's training.
Automation table	A capacity and functionality table which gives information about the components in a system and their energy consumption, voltage, capacities, I/O information, etc.
BAS Integrator	BAS = Building Automation Systems. A person who is authorized to ensure that the processes described in this document are carried out and documented.
BAS Engineer	The person responsible for ensuring that the requirements set in the project by the BAS Integrator are carried out in the design phase.
System Integrator	The person responsible for ensuring that the contract's functional requirements are coordinated, installed, pre-commissioned, and tested.
MOMD	Management Operation Maintenance and Development documentation
BMS	Building Management System

2. Function Maturity Index (FMI)

2.1. Preface

The construction industry has for a long time had a lower productivity development than other industries¹. In addition, many construction projects are characterized by the fact that the technical systems do not function as expected in the final phase of the construction project or when the building is put into operation.

In 2015 a *Guide in Systematic Completion*² to improve productivity in the construction industry, and to ensure that the product actually works correctly and according to the customer's order, was published.

The effects you can expect to achieve by adopting the work processes from Systematic Completion include:

- An error-free construction and technical systems that work as planned when transitioning to regular operation.
- The construction project will be completed and put into use at the agreed time.
- Reduced project costs
- Fewer errors and deficiencies during the construction period (right the first time).
- Reduced energy consumption during operation.
- More accurate operating costs.

In the 7 years that have passed since the guide was finalized in 2015, Systematic Completion has received a relatively large amount of attention, but the industry has invested little in increasing the expertise around the topic. There are still few project owners and project managers who have understood what Systematic Completion actually means for project implementation and what benefits it provides in the final phases.

In several projects, requirements have been set for Systematic Completion, but this has not been followed up in a satisfactory manner. There are no requirements that the methodology and knowledge is understood, and it is not followed up that the methodology is actually used in the projects.

There is also a general lack of people who have the right expertise in management and practical implementation of Systematic Completion.

2.2. The Background for the Function Maturity Index

Systematic Completion challenges the traditional way of thinking about the design and construction of technical systems.

Systematic Completion clarifies requirements for deliveries to the technical systems early in the project, which in traditional projects regularly are delivered too late in the design process. The methodology clarifies the responsibilities of all stakeholders at the right times in the process, a process that also is earlier than in traditional projects. This ensures that tests and verifications in the final phase can be carried out in a predictable manner and with a high probability of a good result.

It can be difficult to follow the work process in Systematic Completion because it challenges the traditional way of thinking. In order to more easily follow up and get a real status of the

¹Statistics Norway: The decline of productivity in construction.

²There is yet no official translation. Link to the Norwegian guide is: <https://www.taskctrl.no/why-systematic-completion>

technical project development, a Function Maturity Index (FMI) has now been developed. It is based on the same thinking as the MMI guide³ for physical objects in BIM, which the industry in Norway has adopted.

The goal of FMI is to establish a common way of communicating how far each individual technical system has come in the development course. The detailed status can be easily aggregated so that the client and the project management can use the index as a measure of how mature the project is regarding Systematic Completion. The index can also be used to understand the order in which the technical systems should be enriched with information so that the order of planning and testing becomes more correct.

2.3. Maturity Levels

To our knowledge, no index has previously been published to describe the maturity of the technical systems. FMI starts with the needs that are the basis for ensuring the correct implementation of Systematic Completion. In addition, FMI provides the opportunity to report uniformly within a project, and between projects, on the status of Systematic Completion.

The Model Maturity Index, MMI, has – in comparison – been established to measure the level of the digital model. To a lesser extent, it is based on the actual construction and testing of technical functionality.

FMI has tried to adapt its levels as far as possible so that they harmonize with the levels of MMI. FMI is designed so that it can be used in various industries, but it is based on the needs of the construction and civil engineering industry.

The Function Maturity Index, FMI, has the following main levels:

FMI100 – Plan for systematic completion established

FMI200 – Functional description per system completed

FMI300 – Table test accepted

FMI400 – System functional test accepted (Site Acceptance Test, SAT)

FMI500 – Integrated tests / full scale tests accepted

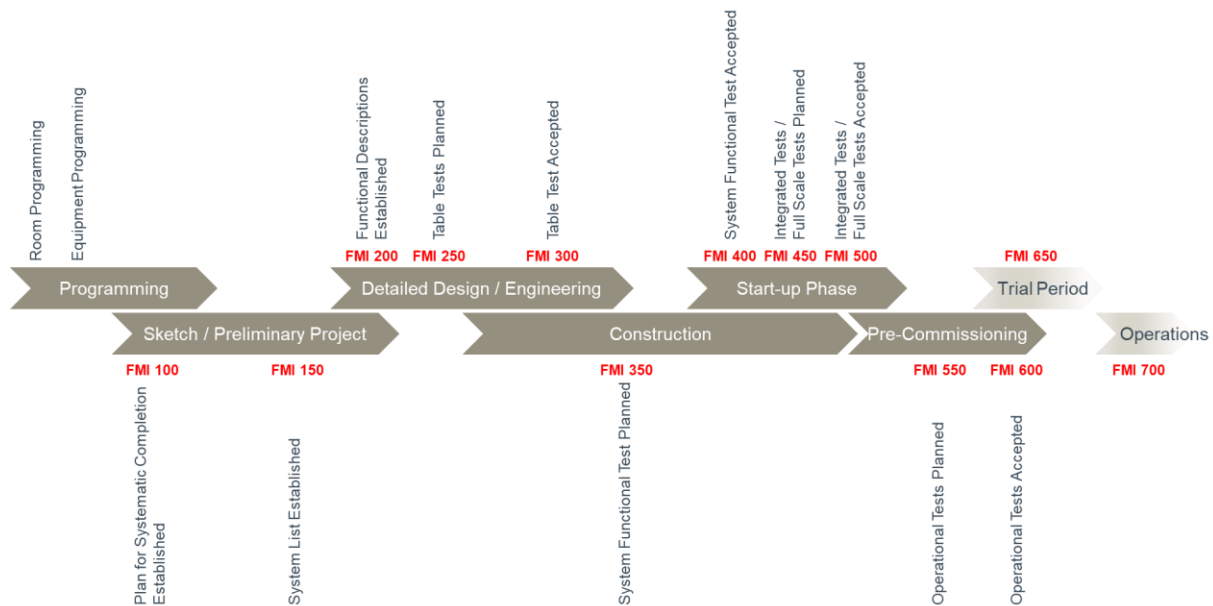
FMI600 – Operational tests accepted

FMI700 – Normal operation

Each project is free to establish indexes between the main levels in order to follow the development even more closely.

The connection between the project's phases and FMI is illustrated in the figure below.

³<https://rif.no/product/mmi-veilederen-2-0/>



3. Basic Principles

3.1. What is the Function Maturity Index (FMI)

The Function Maturity Index, FMI, describes the level of maturity of the technical systems / the technical building installations in a construction project (for both buildings or infrastructures) using unified numerical codes. FMI is primarily a methodology for managing planning and execution as well as being a means to communicate the status achieved during the project's life cycle.

It is not easy to explain to different stakeholders how far in the process a technical system has developed, i.e. which level of maturity it has. It is even more challenging to be able to convey the maturity of a part of a project, or an entire project, when the project consists of a large number of complex interconnected systems.

In Systematic Completion, the sequence in the preparation of various documents is important in order to prepare for correct solutions. Using FMI will make it easier for the stakeholders to ensure correct execution by ensuring the correct work process. The maturity index can also be used to assess the suitability when communicating interfaces and interdisciplinary solutions.

The FMI values are connected or related to the technical systems in order to document the level of maturity in relation to both design, production, and testing along the path reaching completed systems put into operation.

FMI can be used to different extents, from individual systems to smaller areas or entire projects. The index is set on the systems individually but can be aggregated to larger areas or an entire project if the dependence between the various technical systems and clear guidelines for the use of FMI in the project have been fully understood.

3.2. The Relationship Between FMI and MMI

One of the challenges in Systematic Completion is that solutions are often implemented in BIM or schematic drawings before the technical functions are described well enough in the technical functional descriptions. Simply put, it is not unusual for a system to be fully designed without its functionality being fully clarified. This often entails redesigning solutions that have

already achieved an MMI level in BIM. It is therefore important to follow the process in Systematic Completion, and thus FMI, to avoid unnecessary errors and/or unnecessary iterations.

It is recommended to ensure that *FMI200 Functional description completed* is reached before *MMI200 Concept completed* is reached. It can thus be ensured that the design has not progressed too far in BIM before the functionality of the systems has reached the correct level.

3.3. The Use of FMI Levels

The use of the FMI levels described in this guide assumes that these levels are firmly defined and used equally for all players in the industry. Adapted use of the main levels in FMI is therefore not permitted, but there may be a need to detail the intermediate levels in each individual project.

The FMI levels are expected to show the project development. This means that the FMI level for a system can be lowered if iterative planning or many errors in the design and production indicate that the system should belong to a lower maturity level than the level which was set last. It is important that the rules for using the FMI levels are clarified in the individual project already when a *Plan for Systematic Completion* is established. There may be a need to adapt the rules depending on the type, the complexity, and the size of a project.

It will be necessary to define which FMI levels the various systems must follow. For a system with some complexity and interfaces with other systems, it will very likely be necessary to follow the entire maturity process. For a simple system without interfaces, table tests may not be needed. This level can thus be disabled. It can additionally be considered that the simple system does not have to go through a full-scale test and a business test. Such a system can thus be exempted from the maturity levels that are not relevant. The system can thus be given a maturity level jump both from *FMI200 Functional description completed* to *FMI350 System functional test planned* and from *FMI400 System functional test accepted* to e.g., *FMI650 Trial period*.

It is proposed that the FMI levels are set based on the lowest value of what has been carried out in the process. It can in some cases be that a system, individually, has met the criteria for *FMI450 Integrated tests / full-scale tests planned*, while *FMI400 System functional test accepted* has not been met. In that case, it is the level prior to FMI400 that is the status of the system, as FMI400 is not accepted. When FMI400 is eventually accepted, the status in this case will change to FMI450.

3.4. Practical Use of FMI

In the Guide for Systematic Completion with its associated appendixes as well as in NS3935 (NS = Norwegian Standard), various ways of organizing the work with systematic completion are described. The organization will vary depending on the size and the complexity in addition to the chosen contract strategy of the project.

The person most responsible for the implementation of systematic completion in the project, whether it is the project manager for systematic completion or the *BAS Integrator*, defines the rules for how FMI is to be used in the individual project based on requirements set in the contract documents. The rules will also include which FMI levels the various systems must go through.

When a system is to achieve a higher FMI level, it would make sense for a system integrator to suggest the FMI level to be changed and for a systematic completion project manager or an BAS Integrator to confirm/accept that the new FMI level has been achieved – according to the defined accept criteria.

However, it would not be unnatural if the authority to set the different FMI levels in the different phases of the project is delegated. The task can be given to a *BAS Engineer* in the design phase or to a test manager in the phase of installation, start-up, and commissioning.

APPENDIX 1: The FMI Table

Code	Name	Description	Color code**
000	Early phases		
100	Plan for Systematic Completion established	- Plan for Systematic Completion established (strategy and action plan) - Order of commissioning planned - Relationship geometry and functionality for early testing defined - Strategy for early testing established - Rules for using the FMI levels	
125	Reserved*		
150	System list established	- Systems registered in the System List are prepared with location and operating area according to the project's template - General description of technical infrastructure established to ensure the division of technical systems that facilitate early testing - Simplified description of the system's functionality and integrated functions	
175	Reserved*		
200	Functional description (for each system) completed	- Systems registered in the Interface matrix (between systems) and interfaces defined - Integrated functional descriptions including test procedures and acceptance criteria prepared - Functional description ver. 1.0 prepared - System diagram prepared - Automation table prepared	
225	Reserved*		
250	Table tests planned	- Test procedure for table tests incl. acceptance criteria ver. 1.0 prepared - Critical components selected - Draft screenshots prepared - Testplan for all systems (to see the sequence of the testing) established	
275	Ready for table tests	Ready for table tests	
300	Table test accepted	- Execution of table tests - Test accepted incl. completed and adjusted functional description, system diagram, test procedure, automation table, BMS screenshots, test report. - Completed theoretical training of technical systems	
325	Reserved*		
350	System functional test planned (SAT)	- Test procedure for System functional test incl. acceptance criteria ver. 1.0 prepared - Test plan for all systems (to see the sequence of the testing) established	
375	Ready for System Functional Test	Ready for testing according to requirements (MOMD documentation, mechanically completed, energized, complete programmed BMS, etc.)	

Code	Name	Description	Color code**
400	System functional test accepted	- System functional test completed and accepted - Test accepted incl. adjusted functional description, system diagram, test procedure, automation table, test report - Practical training for systems that are carried out	
425	Reserved*		
450	Integrated tests / full scale tests planned	- Test procedure for integrated tests / full scale tests incl. acceptance criteria ver. 1.0 prepared - Test plan (to see the sequence of the testing) established	
475	Ready for integrated tests / full scale tests	Ready for testing according to requirements (MOMD documentation, system functional tests accepted, deviations closed, etc.)	
500	Integrated tests / full-scale tests accepted	- Execution of integrated tests - Test accepted incl. adjusted functional description, system diagram, test procedure, automation table	
525	Reserved*		
550	Operational tests planned	- Test procedure for operational tests including acceptance criteria ver. 1.0 prepared - Test plan (to see the sequence of the testing) established	
575	Ready for operational tests	Ready for testing according to requirements (MOMD documentation, integrated tests accepted, deviations closed, etc.)	
600	Operational tests accepted	- Executing operational tests - Tests accepted and deviations closed - Plant fully operational	
625	Reserved*		
650	Trial period	System put into trial operation	
675	Reserved*		
700	Normal operation	System put into normal operation	
800	Reserved*		
900	Reserved*		

* Reserved for future development of this guide

** Color code for the different levels will be defined for future display in reports and possible display in BIM

APPENDIX 2: An Example of How to Establish the FMI Level

		360.504 Air Handling Unit Laboratory Floors 3 and 4		310.271 Pump Chamber SPV Pump + Drain Pump	
Defined FMI Levels		Planned FMI	Completed FMI	Planned FMI	Completed FMI
100	Plan for Systematic Completion Established	100	100	100	100
150	System List Established	150	150	150	150
200	Functional Descriptions Established	200	200	200	200
250	Table Tests Planned	250	250		
275	Ready for Table Tests	275	275		
300	Table Test Accepted	300	300		
350	System Functional Test Planned	350	350	350	350
375	Ready for System Functional Test	375	375	375	375
400	System Functional Test Accepted	400	400	400	400
450	Integrated Tests / Full Scale Tests Planned	450	450		
475	Ready for Integrated Tests / Full Scale Tests	475	475		
500	Integrated Tests / Full Scale Tests Accepted	500	500		
550	Operational Tests Planned	550	550		
575	Ready for Operational Tests	575	575		
600	Operational Tests Accepted	600	600		
650	Trial Operation	650	650	650	650
700	Operation	700	700	700	700

Status FMI

Status FMI