

**V2M2®**

**A Verification and Validation Maturity  
Model – an introduction**

**V2M2 for test process  
improvement**

V2M2 Platform

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# 1. Preface

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In 2000 a group of Dutch test specialists, managers and researchers gathered at the Technical University of Eindhoven to discuss the importance of testing for the development process and the production of eminent systems. The conclusion was that in many cases testing is still done rather unstructured and ad hoc. As a consequence problems are emerging, like:

- companies loosing the insight in the quality of developed systems or products;
- test processes are not efficient (time consuming) and effective (less concrete and proven results);
- benchmarking of testing activities and results, in- but also outside the company, and through this learning and improving, is almost not possible.

The present available testing improvement models like TMM and TPI were considered as not complete enough to tackle the most important issues. Decided was to start a project group to develop a new and innovative testing maturity model consisting out of instruments for:

- test assessment
- definition and selection of test improvement actions
- measurement of the effects of the improvement actions.

## **The development of V2M2**

The development of the V2M2 model was performed in three phases. The first phase was the subsidized and official part called “the V2M2 project”, the second was called “the application in organizations” and the third “the V2M2 metric base”.

The V2M2 project has involved a number of testing experts from different organizations operating in the Netherlands. These organizations include high-tech industrial companies<sup>1</sup>, software quality service and consultancy agencies<sup>2</sup> and an academic institute affiliated with the Eindhoven University of Technology<sup>3</sup>.

The V2M2 project was sponsored by the Dutch Government, Ministry of Economic Affairs, SENTER Project No. BTS00100.

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<sup>1</sup> Lucent Technologies, Philips Electronics, Thales Naval

<sup>2</sup> Qualityhouse, Improve Quality Services

<sup>3</sup> Frits Philips Institute, Eindhoven University of Technology

The development of a maturity model for the improvement of test processes highly benefited from this unique blend of project participants. The industrial partners were the drivers for applicability, usability, concreteness, economic and business view. The consultancy & service partners emphasized the generic, sale ability, versatility, learn ability and commercial aspects. The academic partner brought in the scientific foundations and counterbalanced the supposed pragmatic orientation of the other project partners.

After delivery of the project result the ownership of the model was taken over by Qualityhouse, a company specialized in software product & process quality. This company started using the model by offering test assessments and test process improvements to its customers. In the period from 2003 until 2006 at least seven successful assessments and improvements were conducted, based on the knowledge and instruments of (the non published) versions 1.2 and 1.3 of the V2M2 model.

During this period a specialized working group<sup>1</sup> was founded to develop the principles for metric based improvement and the improvement space (capability) of organizations. Some research was performed to cover parts of the developed concepts. Finally the present version 2.0 of the V2M2 model was formed, reviewed and published. Not all the review remarks could be processed in this version and more research and discussion will be needed to evaluate them. However this does not obstruct in any way the validity and use of the present version of V2M2.

### **Target group**

The target group for reading and using this publication are specialized managers and consultants in the fields of system development, quality assurance, process improvement and testing. At least a basic level of test knowledge and some years of experience is required. This publication does not give an introduction to testing. Knowledge on the level of ISTQB software testing foundation or practitioner is recommended.

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<sup>1</sup> Faculty of Technology Management, Eindhoven University of Technology, Metrific Management Consult, Qualityhouse

## 1.1. Name of the Model

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The full name of the model is Verification and Validation Maturity Model, abbreviated V2M2.

The name refers to Verification and Validation of products. However, the terms "verification" and "validation" are not uniquely defined in the literature. The same can be said about the term "testing", which is sometimes used as a synonym for Verification and Validation, sometimes in another connotation.

In the context of V2M2 the terms will be used in the meaning given by the National Institute for Standards and Technology (USA; NIST):

**Validation, verification, and testing.** Used as an entity to define a procedure of review, analysis, and testing throughout the software life cycle to discover errors, determine functionality, and ensure the production of quality software [NIST].

Note that this definition is interpreted to cover also hardware and systems.

## 1.2. Backgrounds of the Model

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Despite of the body of knowledge built up on the discipline of software testing, many organizations still struggle with the founding of a sound testing process. One of the reasons is that existing software development maturity models, like CMMI, have not adequately addressed testing issues nor has the nature of a mature testing process been well defined. Guidance for the process of test process improvement is badly needed, as well as a method to measure the maturity level of testing

The V2M2 project partners required that a testing maturity model should be generic applicable (that is, not geared towards a specific type of business) and identified that the model should at least:

- Describe a coherent and generic set of steps and actions to institute and improve a testing process
- Provide well-defined test maturity levels
- Provide an instrument to asses test maturity
- Define measurements to determine the results of improvement actions
- Recommend a metrics basis to select process improvements, to track and control implementation of improvement actions and to adjust and focus the process improvements.

The model was required to minimally address:

- A high degree of compatibility of the test improvement model with process improvements models (like CMM-SW, CMM-I)
- Institutionalization of test methods and techniques

- Set-up of a test organization
- Methods to verify and validate system work products (e.g. review methods)
- Prioritization and reduction methods of test sets
- Feedback mechanisms for defect prevention.

### **1.3. Description of the Content**

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The V2M2 model is introduced in this document by starting a description about the main concepts, methods and instruments of the model.

After the preface in chapter 1, an introduction is given to the model in chapter 2, including an explanation of the framework structure and its components.

### **1.4. Acknowledgements**

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V2M2 was developed in project teams, with varying composition over time. The main author and editor for this 2.0 version was Dirk Kriek.

However his work would not have been possible without the very important contributions of the following people:

Paul Siemons for providing the concepts of the key indicators, the data collection system and the fundamentals of the improvement space.

Jos Trienekens for his broad vision, continuous scientific support, published articles, which served as the basis for assessing the improvement space and his conference tutorials.

Jeff Jacobs for being the first author in putting all the levels and process areas together and for his critical but supportive attitude.

Frans van Veen for working out the improvement space principles into concrete and workable questionnaires.

Daniel Maton for his ideas and pictures of the continuous test process.

Kasper Dortland, for performing his improvement space research.

The following people have been involved in writing and reviewing the process areas and practices or in reviewing the complete model: Jan van Moll, Erik van Veenendaal, Paul Dieleman, Ron Snijders, Martijn van Ham, Ben Rendering, Sabrine ter Braak, Ton Lagedijk, Kees Blokland, Ron Snijders, Ron Swinkels, Dirk Kriek, Jeff Jacobs, Jos Trienekens, Anke van der Moer, Andre Smeets, Luuk Soetens.

Special thanks goes to the management of Qualityhouse, Roel van der Meulen and Matheu Panders who saw the possibilities and the importance of the concepts and instruments and who became the main sponsors of V2M2.

## **1.5. Feedback and Additional Information**

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We welcome your ideas for improving V2M2. See the V2M2 Website for information on how to provide feedback:

<http://www.v2m2.com>

This Website also provides additional information on the model and related issues.

## 2. Model concept, structure and components

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### 2.1. Conceptual Basis

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The first step towards the definition of a framework for V2M2 was an extended inventory and examination of existing improvement models and an evaluation of their fit to the consortium's model objectives. Among the models investigated were general software improvement models like CMM and its successor CMM-I<sup>1</sup>, SPICE, Bootstrap, and software testing specific models like TMM, TPI<sup>2</sup>, TAP, MMAST, TCMM, TSM, and TOM, including comparisons of models.

It was found that TMM (Testing Maturity Model) provided the most suitable basis. The main reasons for this were that this model already seems to fulfill some of the V2M2 objectives, like well defined test maturity levels and the set up of a test organization. Furthermore TMM reflects over forty years industry-wide software testing evolution and was designed to be a counterpart of the software process improvement model CMM.

TMM (Testing Maturity Model) developed, in 1996 at the Illinois Institute of Technology<sup>3</sup> reflects the evolutionary pattern of testing process maturity growth documented over the last several decades, as outlined in a historical model provided by Gelperin and Hetzel. A definite strength of TMM is that it is founded on forty years of industrial experience with software testing. It profits from many past struggles to find a sound software testing process. Also a strong point of TMM is its design objective: to be a counterpart of the popular software process improvement model CMM. Software process improvement programs can use TMM to complement CMM, as CMM and also CMMI do not adequately address testing issues. On the other hand, it is also possible to improve the testing process independently, though one should be aware that maturity levels for testing and software development must remain close to each other.

In addition, the literature was scanned for best test practices and test standards as a preparation for later process area definitions. The literature scan also included approaches for development and application of metrics, as a preparation to the development of a metrics base for V2M2.

The V2M2 model integrated the strengths of those other models and added new ideas, research and practical experience resulting in:

- A detailed specification of processes and practices
- Process areas for test environment and for organizational alignment

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<sup>1</sup> CMM and CMM-I are registered service marks of Carnegie Mellon University.

<sup>2</sup> TPI registered by Sogeti Nederland B.V.

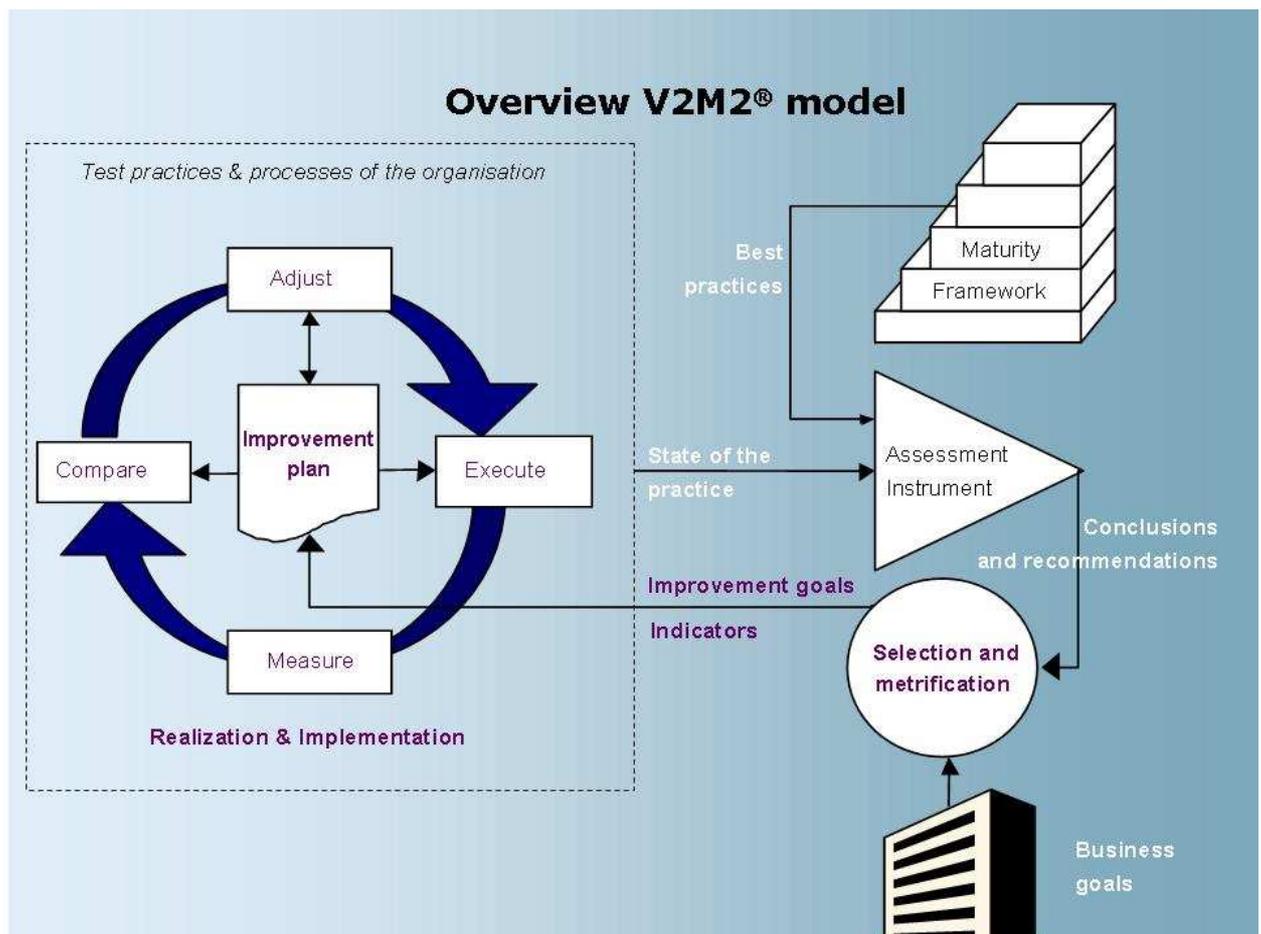
<sup>3</sup> TMM is a registered service mark of Illinois Institute of Technology.

- A method for metric based improvement
- Strong framework compatibility with CMM and CMMI
- A professional assessment instrument
- Improvement targets take into account the improvement space
- A foundation in research and experience

*“We have noticed that your V2M2 model is a very comprehensive and universal framework for the improvement of testing functions. The development of V2M2 model has required fundamental examination of previous known improvement models. Strengths and weaknesses of those models has been considered in the development of V2M2.” – NTC. (Northern Test Center <http://www.ncemforum.org/>)*

## 2.2. Model Overview

V2M2 is more than a maturity framework. All the elements strengthen each other in achieving the needed improvement goals. The complete V2M2 model is shown in the next figure.



**Figure 1 an overview of the V2M2 model**

The V2M2 model consists of four basic components:

1. The maturity framework

A set of best practices in testing, grouped into a tight structure of process areas and maturity levels. The structure serves as a key reference for how testing can be done ensuring increasing transparency, control, repeatability and improvement.

2. The assessment instrument.

A set of components like questionnaires, ranking algorithms, strength-weakness analysis reports and improvement recommendations compliant with the ISO 15504 standard for assessments. This assessment is a procedural way to assess the state of testing in an organization by taking the V2M2 maturity framework as a reference. In V2M2 version 2.0 the assessment has been extended with inquiries about the improvement capability and the presence of quantitative historical data.

3. Selection and metrification

This mechanism aims at selecting & measuring the test improvement activities and their effects. The business- and test goals of the organization are used in an improvement definition process which consists of selection, prioritization and metrification. In this way V2M2 will ensure improvements, which primarily focus on the needs and benefits of the organization and secondly on the maturity level prescribed by the model.

4. Realization & Implementation

The improvement realization & implementation process is, as a kind of Deming wheel, positioned in the midst of the organizations test processes and practices. This symbolic position is to emphasize the necessity of interaction between the improvement goals and the daily practices and activities. Realization focuses on the creation of those improvement items which are supportive to the realization of the improvement goals. Implementation is the use of the improvement items in the actual process.

### **The improvement flow in V2M2**

Figure 1 shows a dotted rectangle which represents the set of all documented and non documented test processes and practices which are used by the organization. When starting the V2M2 improvement process this set is assessed with the V2M2 assessment instrument and compared with the V2M2 framework.

It results in conclusions and recommendations which serve as input for the next step: selection and metrification. The output of this process is an improvement plan with improvement goals and indicators for measuring the improvement results. The improvement plan serves as a guideline for the improvement realization and implementation process. This process becomes metric based by the usage of the indicators and the constant comparing of the results with the goals and adjusting the activities or goals accordingly. The metric based parts are shown in Figure 1 as purple text.

## 2.3. Terminology

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The terminology used and how it is defined are important to understanding the content of V2M2.

### **Adequate, Appropriate, As Needed**

These words are used so that you can interpret process area descriptions in the light of your organization's business objectives and operations. These terms are used in goals and practices where certain activities may not be done all of the time.

### **Business Management**

The highest management entity responsible for operating the organization in all its aspects. Business Management provides guidance to the business' operations and is entitled to take strategic decisions to ensure continuity of the organization on the longer term.

### **Functional Management**

The management entity directly responsible for a clearly bounded aspect of the business operation. Functional management is the first responsible entity for non-strategic, operations-centric decisions.

### **Stakeholder**

A "stakeholder" is a group or individual that is affected by or involved in an undertaking. The term "relevant stakeholder" is used to designate a stakeholder that is identified for involvement in specified activities and is included in an appropriate plan.

### **Manager**

The word "manager" refers to a person who provides technical and administrative direction and control to those performing tasks or activities within the manager's area of responsibility. The traditional functions of a manager include planning, organizing, directing, and controlling work within an area of responsibility.

### **Project Manager**

A "project manager" is the person responsible for planning, directing, controlling, structuring, and motivating a development project. The project manager is responsible for satisfying the customer.

### **Test Manager**

A "test manager" is the person responsible for planning, directing, controlling, structuring, and motivating a test project. The test manager is responsible for satisfying the customer of the test project, which is in most cases the project manager of the development project.

### **Organization**

An organization is typically an administrative structure in which people collectively manage one or more projects as a whole, and whose projects share a senior manager and operate under the same policies.

### **Development**

The word "development," implies not only development activities, but also maintenance activities.

### **Test Project**

A “test project” is a managed set of interrelated resources that delivers one or more test related products to a customer or (end) user (often a development project), like test plan, test design, test scripts, test reports. It uses the same principles as a project.

### **Product**

The word “product” is any tangible output or service that is a result of a process and that is intended for delivery to a customer or (end) user. A product is a work product that is delivered to the customer.

### **Work Product**

The term “work product” is used to mean any artifact produced by a process. These artifacts can include files, documents, parts of the product, services, processes, specifications, and invoices.

### **Assessment**

An “assessment” is an appraisal that an organization does to and for itself for the purposes of determining its maturity level, the adequacy of its processes and to indicate directions for process improvement. The word “assessment” is also used in an everyday English sense (e.g., risk assessment).

### **Standard**

When you see the word “standard” used as a noun, it refers to the formal mandatory requirements developed and used to prescribe consistent approaches to development (for example, IEC/ISO standards, IEEE standards and organizational standards). Instead of using “standard” in its common everyday sense, we chose another term that means the same thing (for example, typical, traditional, usual, customary).

## 2.4. Maturity Framework

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The staged framework is considered to be the main structure in which the test processes and test practices are worked out. Each maturity level addresses different process areas, although some process areas, like planning could be addressed at multiple maturity levels. In this version 2.0 the continuous view on the test process is added. It is defined and elaborated in the full version of V2M2 and shows how basic test processes, which are described in several framework process areas, can evolve to higher maturity levels.

This and the next two paragraphs will explain the structures of the staged framework.

### **Maturity Levels**

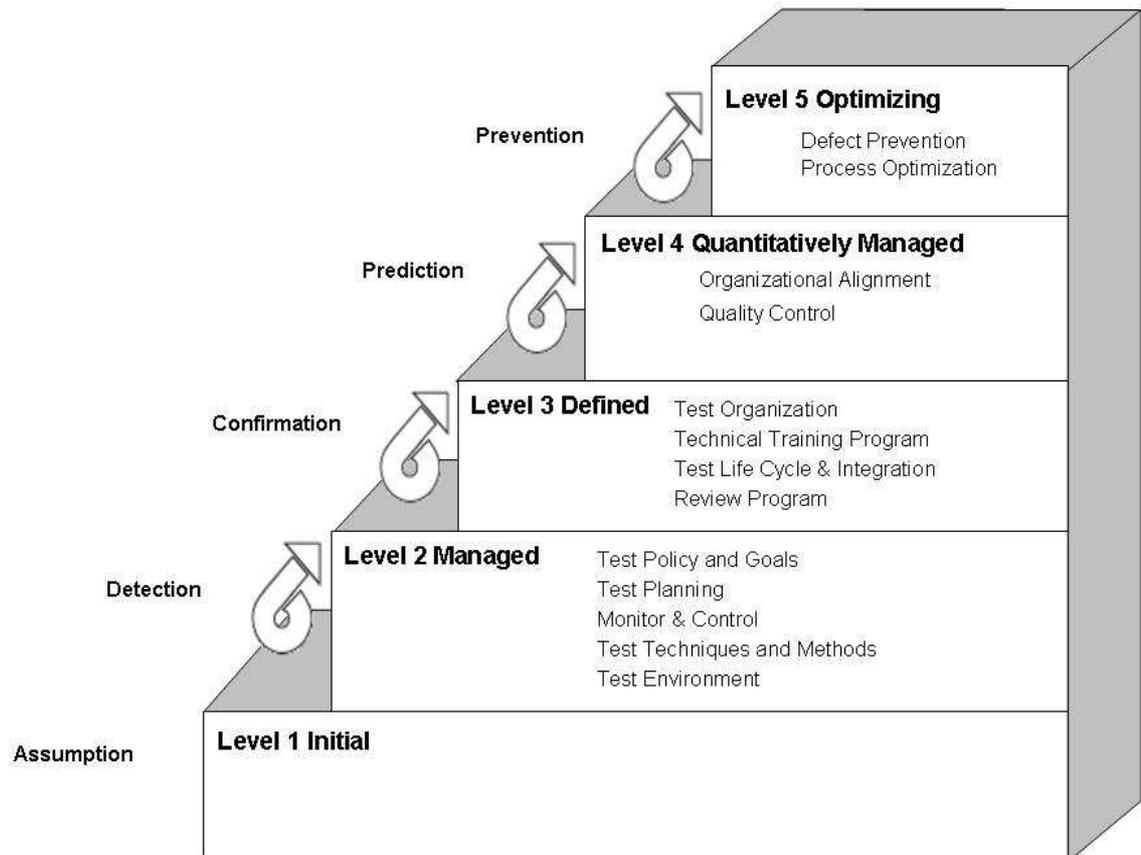
A maturity level is a well-defined plateau of process growth. Each maturity level stabilizes an important part of the organization's processes. Maturity levels consist of a predefined set of process areas. The maturity levels are measured by the achievement of the goals that apply to each predefined set of process areas. The model consists of five maturity levels each layer being the basis for ongoing process improvement: Initial, Managed, Defined, Quantitatively Managed, Optimizing. The general direction of the growth of maturity is towards more control and standardization which reduces the variation of the processes, culminating in more efficiency and less product outfall.

### **Process Areas**

A process area consists of a set of related practices in an area that, when performed collectively, satisfy a set of goals considered important for making significant improvement in that area.

### **Maturity Framework**

The framework of the model with its maturity levels, process areas and visions on testing can be graphically represented as in Figure 2.



*Figure 2 Maturity levels and Process Areas of V2M2*

## 2.5. Maturity Levels and Process Areas

### Maturity Level 1: Initial

Maturity Level 1 is the initial level and has no process areas. The main objective of testing is to show, in an ad-hoc way, that products work. Testing is a spiral of finding and correcting problems, performed by too few and untrained people.

On this level testing is characterized as “Assumption”, which means that no systematic preparation, executing and known coverage of testing is expected and that the result will depend upon the expertise, effort and moods of the involved people. When released no clear and traceable test results are delivered, the coverage is unknown and it is assumed that the system is working “good enough”.

### Maturity Level 2: Managed

Purpose of maturity level 2, the Managed level, is the establishment of a basic verification and validation process. By the introduction of basic test practices in the projects, a basic testing process emerges. The objective of testing is now “Detection”, i.e. defect detection. Systematic testing is implemented to achieve better levels of process control and achieving

higher levels of defect detection. Testing is planned, performed and documented. Testing and debugging are considered to be different activities. Tests are conducted in a dedicated test environment. When all the practices are in place, projects are performed and managed according to their documented test plans.

When an organization wants to improve its verification and validation process, it should first clearly define its test policy. The test policy defines the organization's overall test objectives, view points regarding the goals of testing and the level of independence. It is important that the test policy is aligned with the overall business and quality policy of the organization. A test policy is necessary to attain a common view on testing between all relevant stakeholders within an organization. This common view is indispensable to align further test process improvement activities.

Once the organization has defined its policy for and its goals of testing, the other process areas can be established, in any order or concurrently.

### **Maturity Level 3: Defined**

Purpose of maturity level 3, the Defined level, is to further organize and embed testing into the organization's development life cycle.

Testing has become a real verification of requirements as laid down in a specification document. Testing is done according to an organization wide defined and repeatable test process, which is documented in standards and procedures and by using tools and methods. Testing already starts at the requirements phase and continues throughout the entire life cycle. A test organization is in place and testing is recognized as a profession, including a career development plan and associated training program.

The organization's test process is established and improved over time. This standard test process is used to establish consistency across the organization and is described in more detail and more rigorously than at maturity level 2. Projects establish their defined processes by tailoring the organization's set of standard processes according to tailoring guidelines.

The character of testing is evolving more and more from defect "Detection" to "Confirmation", i.e. creating evidence through complete validation & verification that the requirements are correctly implemented in the system.

### **Maturity Level 4: Quantitatively Managed**

Purpose of maturity level 4 is the establishment of testing as a quantitatively controlled measurement of products, supported by a quantitatively managed test process. The conditions to operate at this level are created by aligning the way-of-working with other organizational entities. Especially the alignment with Development is a prerequisite because it is practically impossible to create a statistically controlled test process without bringing the complete development process to that level. Quantitative measurements and statistical techniques and methods control the test process.

The character of testing has evolved to “Prediction”, i.e. testing is used as early as possible to predict the product quality in next levels of system realization, especially on the post release level.

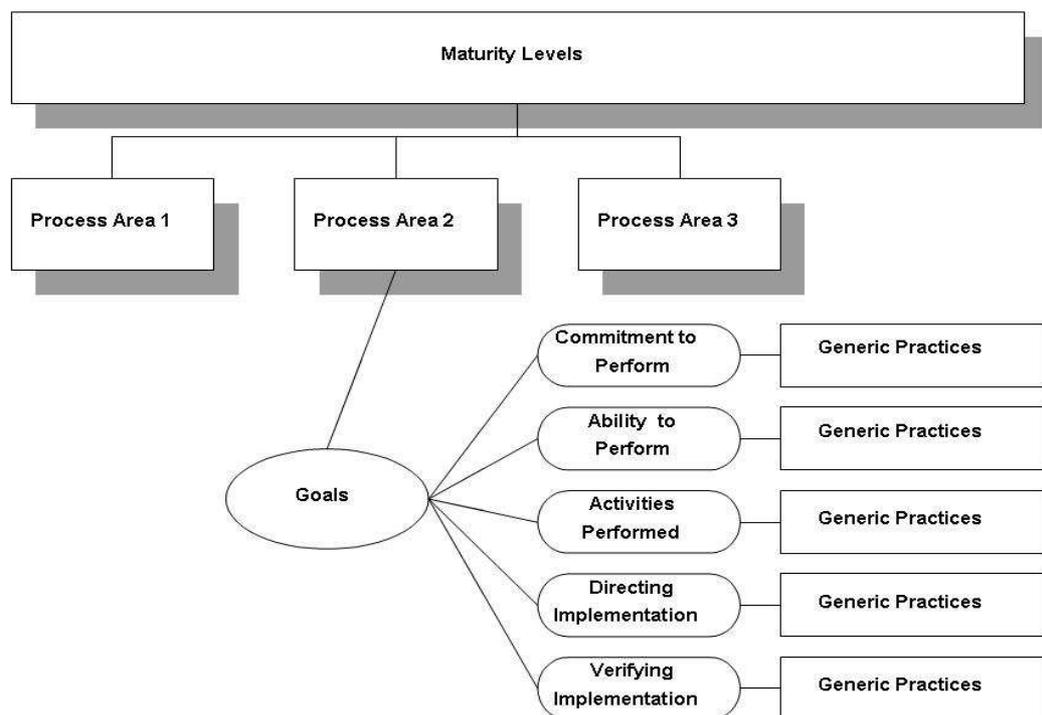
### Maturity Level 5: Optimizing

Purpose of Maturity Level 5, the Optimizing level, is to fine-tune and optimize the testing process on a continuous and structured basis. Costs, efficiency and effectiveness are continuously quantitatively measured. Defect causal analysis and defect prevention are common practice. The testing process is continuously monitored and improved.

The character of testing has evolved to “Prevention”, i.e. testing results and defect registration is used to discover the root causes of certain defects.

## 2.6. Maturity Framework Structure

V2M2 describes process areas in a CMM/CMMI-like way. Figure 3 shows the structure of the maturity framework.



**Figure 3 - Structure of the Framework**

The structure does not use, like CMMI, a separation between specific and generic goals. For the purpose of testing maturity this was considered to create more work and redundancy without giving enough added value. The goals are like in CMM specific goals and the corresponding activities are like in CMMI structured in equal groups called generic practices. See below for further explanation.

## Common Features and Generic Practices

Common Features are predefined attributes that group Generic Practices into categories. Common Features are model components that are not rated in any way, but are used only to structure the Generic Practices. Five Common Features are distinguished, structuring a total of ten Generic Practices, as shown in Table 1 below, and detailed in the remainder of this section.

Common Features	Generic Practices
Commitment to Perform	<ul style="list-style-type: none"> <li>• Policy</li> </ul>
Ability to Perform	<ul style="list-style-type: none"> <li>• Resources</li> <li>• Responsibility</li> <li>• Training</li> <li>• Process</li> </ul>
Activities Performed	<ul style="list-style-type: none"> <li>• Activities</li> </ul>
Directing Implementation	<ul style="list-style-type: none"> <li>• Configuration Management</li> <li>• Measurement</li> </ul>
Verifying Implementation	<ul style="list-style-type: none"> <li>• Adherence</li> <li>• Review</li> </ul>

**Table 1 overview of Common Features and Generic Practices**

### Commitment to Perform

- (Establish an Organizational) Policy

The purpose of this generic practice is to define organizational expectations for the process and make these expectations visible to those in the organization that are affected. In the process area descriptions, this generic practice is indicated as “Policy”.

### Ability to Perform

- (Provide) Resources

The purpose of this generic practice is to ensure that the resources necessary to perform the process as defined by the plan are available when they are needed. Resources include adequate funding, appropriate physical facilities, skilled people and appropriate tools.

- (Assign) Responsibility

The purpose of this generic practice is to ensure that there is accountability throughout the life of the process for performing the process and achieving the specified results. The people assigned must have the appropriate authority to perform the assigned responsibilities.

- Training (People)

The purpose of this generic practice is to ensure that the people have the necessary skills and expertise to perform or support the process. Appropriate training is required to the people who will be performing the work.

- (Create a) Process

The purpose of this generic practice is to provide steps or procedures which are necessary to have ready before performing the activity practices of the process area. When ready these processes can be added to an organization wide collection of processes. When growing to higher levels of capability these processes can through adaptation, evaluation and selection evolve to defined processes. With a defined process, variability in how the processes are performed across the organization is reduced; and process assets, data, and learning can be effectively shared.

#### Activities Performed

- Activities

The purpose of this generic practice is to describe the activities that must be performed to establish the process.

#### Directing Implementation

- Configuration Management

The purpose of this generic practice is to establish and maintain the integrity of the designated work products of the process (or their descriptions) throughout their useful life.

- Measurement (of the Process)

The purpose of this generic practice is to perform direct day-to-day monitoring and control of the process and to collect information derived from planning and performing the process. Appropriate visibility into the process is maintained so that corrective action can be taken when necessary.

#### Verifying Implementation

- (Objectively Evaluate) Adherence

The purpose of this generic practice is to provide credible assurance that the process is implemented as planned and satisfies the relevant policies, requirements, standards, and objectives. People not directly responsible for managing or performing the activities of the process typically evaluate adherence.

- Review (Status with Business Management)

The purpose of this generic practice is to provide business management with appropriate visibility into the process. Business management includes those levels of management in the organization above the immediate level of management responsible for the process.

## 2.7. Assessment Instrument

The assessment instrument is a combination of questionnaires, a ranking system, checklists and templates embedded in an assessment procedure.

The instrument as shown in Figure 4 is split in three sub instruments:

### 1. Pre-assessment

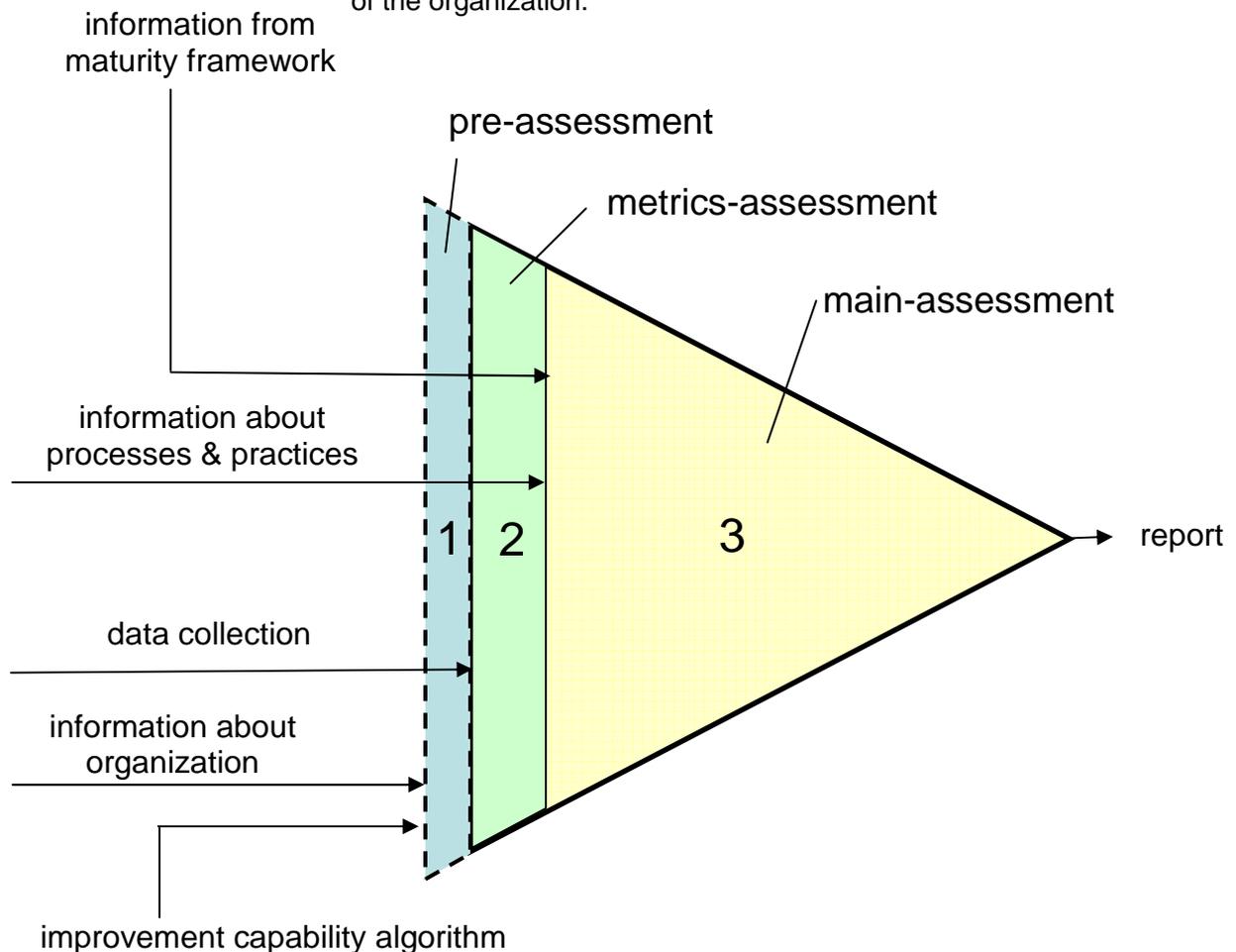
The purpose of the pre-assessment is to assess the organizations capability to improve, mainly based on a determination of the organizations balance between their inner and outer world.

### 2. Metrics assessment

The purpose of the metrics assessment is to collect or estimate fundamental metric data about defects, size, effort and duration in order to assess the organizational performance and to support the main assessment.

### 3. Main assessment

The purpose of the main assessment is to assess the testing capability of the organization.



**Figure 4 – V2M2 assessment instrument**

The assessment procedure supports the assessment instruments and consists of the next three parts.

### 1. Preparation

The purpose of the preparation part is to determine the scope and depth of the assessment and to prepare for an optimal assessment performance.

### 2. Execution

The purpose of the execution phase is to collect all necessary information through interviews, document studies and other means to be able to evaluate the test processes and practices of the organization. If also the improvement and metric assessment is executed than it also possible to evaluate – to a certain extent - the organizations expected capability to improve and the organizations test performance.

### 3. Reporting

The purpose of the reporting phase is to determine the testing capability according to V2M2 framework, to determine the strong and weak points, to recommend improvement items and to report the results to the involved people.

## **2.8. Selection and Metrification**

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The selection & metrification process is meant to select those improvement items which are most needed for- or wanted by the organization. During selection a procedural structure is used for prioritizing and aligning the improvement items with the business goals. The metrification part couples metrics to the improvement items according to the methods described in the full version of V2M2 about metric based improvement.

## **2.9. Realization & Implementation**

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The purpose of the realization & implementation process is the successful establishment in the organizations test projects of the agreed improvement goals. The improvement plan serves as a guide for this process. Therefore it contains the full strategy and planning to realize and implement the chosen improvements.

The complete metric based improvement process is a combination of the selection, metrification, realization and implementation of the improvement goals. A set of basic generic metrics is used to track the improvement plan progress and the improvement results.

Because this metric based improvement forms the core of the growth to higher performance it is immediately elaborated in the next chapter. After it the other V2M2 model parts, the assessment instrument and the practices of the maturity framework, are explained by going backwards through the model-flow described in Figure 1.