German V&V Case Studies – Experiences and Lessons Learned

Prof. Dr. Axel Lehmann
Universität der Bundeswehr München
und
ITIS GmbH
GERMANY

Axel.lehmann@unibw.de

ABSTRACT

Measures for verification and validation (V&V) of models, simulations and data (M&S) have been always important aspects and caused specific activities ensuring quality and utility of M&S results and their interpretation. Along with rapid innovations and increasing performance of computer systems, networks and software, capabilities as well as complexity of models and simulations are permanently increasing. Therefore, major M&S challenges nowadays concern mastering of M&S complexity as well as development of measures for quality assurance regarding correctness, validity and usefulness of models, simulations and its data. This contribution presents a summary of experiences gained by the development and practical application of national process and documentation guidelines for M&S development, verification and validation.

1.0 OVERVIEW OF THE INTEGRATED QUALITY ASSURANCE STRATEGY

In parallel and in context of international standardisation activities of SISO-PDG-GM-VV, MSG-054 and MSG-073, the German Armed Forces and its Procurement Office (BWB) had launched some case study projects for development and application of national guidelines in accordance with international standards or guidelines like GM-VV ([20]). This paper is a brief summary of essential aspects and lessons learned by application of these national guidelines in two case studies ([1], [16]).

1.1 Guideline for Model Documentation

The documentation guideline defines core requirements of structure and content of work products and documentation, and it provides templates for documenting an M&S project and its associated V&V efforts throughout the entire model development life cycle. As shown in Figure 1, the essential elements of this documentation guideline are adapted from GM-VV based on a meta-model description including role concept, document templates, methodological support, and a tailoring concept ([1]).

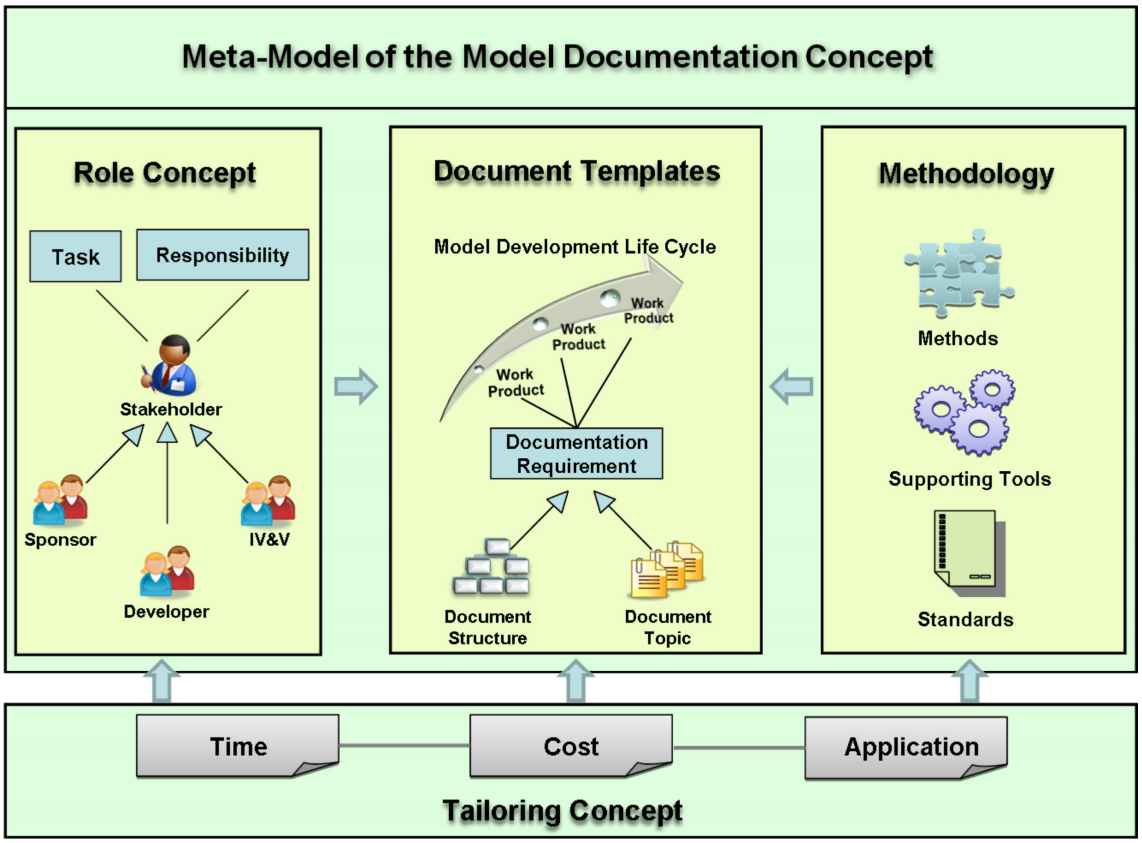

Figure 1: Documentation guideline ([1]).

1.1.1 Meta Models

The fundamental structure of the guideline is illustrated in the form of a set of meta models, which serve as common basis to describe the introduced core elements, such as role concept, documentation templates, supporting and tailoring concept, their semantics and relationships between these elements. In addition, all meta models are specified and organized in different degrees of abstraction to meet the specific needs of each user group of this guideline ([1], [2]).

1.1.2 Roles and Responsibilities

In order to define functional tasks and competencies for persons participating in model development, documentation and V&V activities, a well-structured role concept is introduced. During the process of project planning, roles are assigned to individuals or organizational units with certain responsibilities, e.g. contributory or decisive responsibilities. While several roles may support in the creation of a product, exactly one responsible role can be assigned to each work product. Since an M&S project should normally involve three kinds of parties [5], namely participants from the sponsor side, the developer side, and the Independent V&V (IV&V) [6], this role concept has been developed in a manner which offers an organization-independent orientation for project management. Figure 2 shows the relationship between roles, their responsibilities, and tasks defined in this documentation guideline.

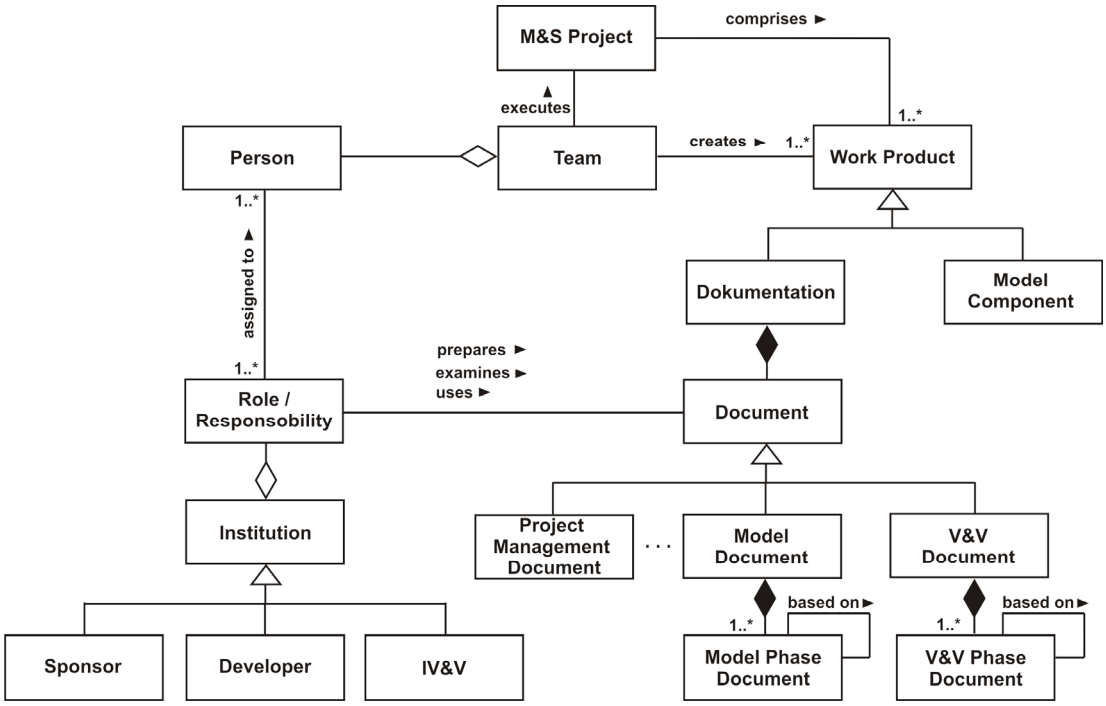

Figure 2: Roles, responsibilities, and tasks ([1]).

1.1.3 Documentation Templates

To facilitate the proposed model documentation activities, concrete structure and content requirements for each work product created during the M&S life cycle are specified in the form of documentation templates. A structured process for developing M&S applications and conducting their V&V was applied as the reference process as developed by [2], [3], [7].

As shown in Figure 3, this national documentation guideline provides detailed documentation templates for the description of Sponsor Needs (SN) and for work products in the different model development phases, such as Structured Problem Description (SPD), Conceptual Model (CM), Formal Model (FM), Executable Model (EM), and Simulation Results (SR). In accordance with GM-VV and with respect to compatibility with other international M&S concepts [7], [8], or guidelines and standards like REVVA [13], IEEE 1516.4 [9], and DoD Standard Practice [11], these have been taken into account too. Thus, all of the proposed templates can be directly applied to an M&S project or adapted as required before use.

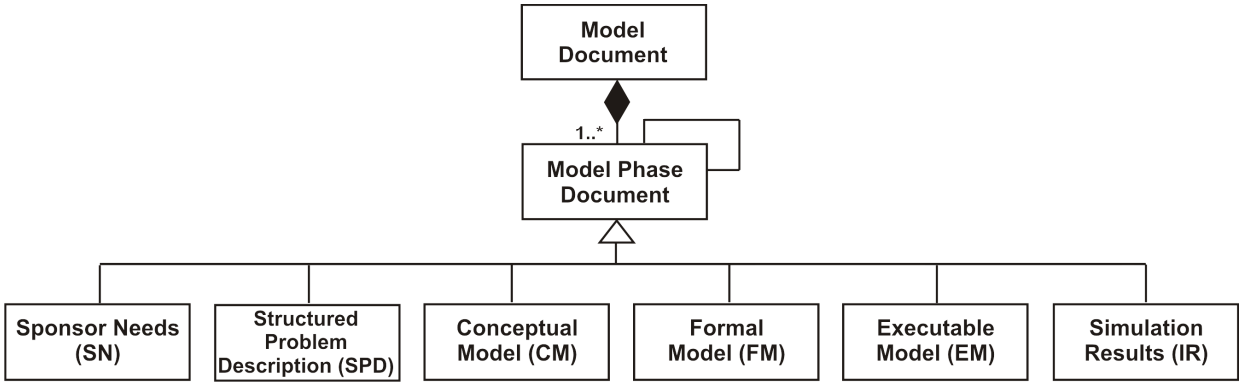

Figure 3: Document templates for the different M&S work products ([1]).

1.1.4 Methodological Support

This documentation guideline also contains recommendations of selected practical methods, supporting tools, and standardized processes (e.g. the German V-Modell XT [12], [14], [15]) by means of which each potential user could find a more efficient way of preparing documents for model development and its V&V, as well as exchanging data (or information) among all involved project participants.

1.1.5 Application of the Proposed Tailoring

Because of different characteristics of organization structures and project environments, this model documentation guideline needs some kind of adaptation or tailoring prior to application. For this purpose, a multistage tailoring concept is developed, which enables the project-specifiic selection of essential products, documents, and activities for developing M&S applications and conducting their V&V according to specified cost, time, and application constraints. By applying this tailoring mechanism, only relevant M&S products have to be taken into account during the model development process. This implies a reduction of project complexity.

1.2 A Generalized V&V Concept – The "V&V Triangle"

As Figure 4 illustrates, two closely associated parts of V&V activities (model V&V and data V&V) are specified for application as part of model development [1], [2]. As an example, this model development process defines five modeling phases (depicted as black boxes) and their related work products. These development phases symbolize sets of activities to transform one work product into its successor.

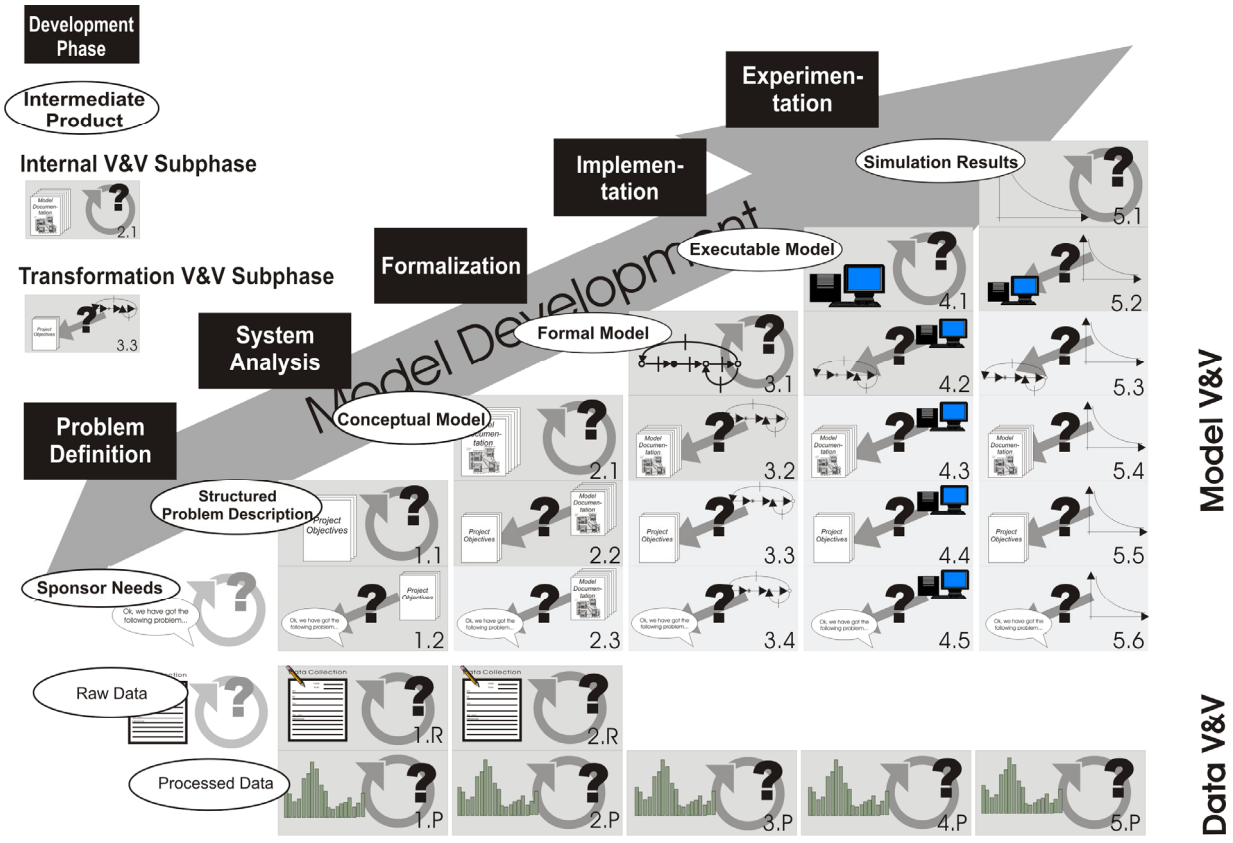

Figure 4: The "V&V-Triangle" ([1], [2]).

The V&V process is organized as a triangle-like matrix. The columns of the matrix represents the V&V main phases, which are associated with the work products (also referred to as intermediate products); while intersections between the columns and rows split the V&V main phases into V&V sub-phases. During V&V, each work product is examined for internal consistency and completeness with respect to the intended purpose of the model. Subsequently, the transformation consistency is checked by pair-wise comparison of all work products. Regarding model V&V, one work product is input to a V&V phase, numbered 1 through 5. Each V&V phase is again split into sub-phases, each with a defined sub-aim to detect the internal defects or transformation defects. In each sub-phase numbered as x.1, the absence of internal defects in each particular work product should be demonstrated. For example, in sub-phase 1.1, it should be ensured that the problem description is free of misunderstandings and inconsistencies, and in sub-phase 3.1, a syntax check can be applied to the formal model for comparison of the chosen formalism. In any other sub-phase, the pairwise comparison between the current work product and each previous work product can be performed to confirm the absence of transformation defects. For instance in sub-phases 3.2, 3.3, and 3.4, the formal model could be compared with the conceptual model, the structured problem description, and also the sponsor needs.

With respect to data V&V, two types of data should be distinguished: raw data and processed data. Raw data are obtained directly from different sources, which are in general unstructured and unformed data. Processed data are, however, created by analyzing, editing, transforming, or adapting raw data during the modeling process. Thus, data V&V involves credibility assessment of raw data and processed data, which are essential for creating a work product. It should be noted that raw data are usually only relevant for specifying products in early model development phases, for example Structured Problem Description and Conceptual Model, and are not directly applicable for products like Formal Model and other succeeding products. Therefore, the associated V&V of raw data are undefined for certain work products [3].

2.0 CASE STUDIES

This section describes the two pilot projects planned for applying the proposed quality-assurance strategy. Both projects, sponsored by the German Armed Forces and its Procurement Office (BWB), are concerned with development of training simulators being designed and developed by the simulation software company szenaris. While the main emphasis of the first project was a case study on quality assurance of a pontoon bridge training simulator which focused on introduction and application of a specific M&S documentation guideline including a tailoring concept. The second project, a case study of a robot training simulator, focused on applicability and effectivity of the “V&V Triangle” concept and a graph-based V&V concept for root cause analysis ([7], [15], [20]).

2.1 Quality Assurance of a Pontoon Bridge Training Simulator (Case Study for Application of the Documentation Guideline and Tailoring)

In parallel with the development of apontoon bridge team-training simulator (see Figure 5), the application of the proposed documentation and tailoring concepts was defined as case study, which was conducted cooperatively by the project sponsor (BWB), the M&S developing institution (szenaris GmbH), and the coaching institution (ITIS) [16]. While the M&S developers had to design and to develop the training simulator according to the proposed concepts, they had to provide the work products plus model documentation for each development stage presented in Figure 4. At he same time, the coaching institution (ITIS) had to provide coaching for the documentation activities, had to review the M&S development process, and to evaluate the quality of the M&S process and completed model documents.

Figure 5: Pontoon bridge team training simulator.

2.1.1 Scope of this Case Study

Due to the time and cost limits of this case study, it was only feasible to select and document a subset of the developed M&S work products. Therefore, the tasks and activities of the two parties were adapted as follows:

- M&S developers (szenaris GmbH) activities and tasks were
  - To select a consistent subset of the model and assocviated work products by application of the proposed tailoring concept,
  - To prepare the required M&S work products and documents for each M&S development phase according to the documentation guideline and templates, and
  - To provide a preliminary cost-benefit analysis for application of the applied M&S development guideline.
- Coaching institution (ITIS) activities and tasks were
  - To coach M&S documentation procedures and tailoring activities according to the proposed guideline,
  - To check – as far as the subset of work products and associated documentation allowed – correctness and consistency (also for an estimation of documentation and V&V efforts), and
  - To gather feedback for further development of the model documentation guideline and tailoring concept.

2.1.2 Results and Experiences

After selecting a subset of the Sponsor Needs with respect to the actual project conditions, the developer began to document the model being developed according to the documentation guideline. The prepared model documents in each development phase were then inspected by the coaching institution. The inspection focused on (1) whether the prepared model documents formally met the requirements of the proposed guideline and (2) whether they were correct and consistent with respect to the selected subset of the M&S requirements. The objective of the inspection was not to conduct V&V of the overall simulation model being developed officially, but rather to acquire a preliminary effort estimation of application of this documentation guideline.

Following the guideline instructions, M&S documentation in this case study was conducted in an iterative manner. Hence, as shown in Table 1, there exist different but consecutive developed work product and document versions for each M&S phase. Compared to seven document versions of CM, only two documents of FM were prepared. This was due to the fact that a commercial off-the-shelf (COTS) simulation environment "Virtools" was applied to the development of the training simulator [17]. Since physical behaviors and interactions of all the objects considered in the simulation study were black box implementaions by means of the "Havocs Physics Engine" [17] integrated in the simulation environment of Virtools, no complete work product FM was accessible for external review (only parts of it). Therefore, a complete FM-V&V review was not feasible and excluded from further investigations. In the two document versions of FM, these reasons for tailoring by reduction of M&S documentation and associated V&V efforts were documented. The single document of SR included both operation protocols and data of differentsimulation test scenarios.

Table 1: Model documents prepared in the case study.

Predefined work products	Document versions
Structured problem description (SPD)	5
Conceptual model (CM)	7
Formal model (FM)	2
Executable model (EM)	7
Simulation result (SR)	1

Table 2 and Table 3 show the share of workload directly related to the model documentation and coaching activities. Following the proposed M&S development guideline and documentation proceduresas described above in this case study, total efforts of the coaching institution was about 1/3 of the efforts spent by M&S developers [16].

Table 2: Documentation efforts of the developer (working days).

Work expended	Percentage
1. Guideline introduction and planning	16.5
2. Preparing the model documents	58.5
3. Quality assurance	10.0
4. Workshops and meetings	15.0

Table 3: Coaching efforts (working days).

Work expended	Percentage
1. Introduction of the documentation concept	25
2. Inspection of the model documents	60
3. Workshops	15

2.2 Verification and Validation of a Robot Movement Training Simulator (Case Study for Application of the Proposed V&V Concept and Guideline)

As the focus of the previous case study was focused on application of the proposed M&S documentation guideline and tailoring concept, a further investigation of the proposed V&V concept and associated V&V process guideline was defined in the context of the development of a robot movement simulator (see Figure 6). As in the previous case study, the same institutions were closely cooperating – BWB as project sponsor, szenaris GmbH as M&S developer, and ITIS as external V&V agent. Similar to the former project, application of the M&S development guideline together with "V&V Triangle" and graph-based V&V had to be performed.

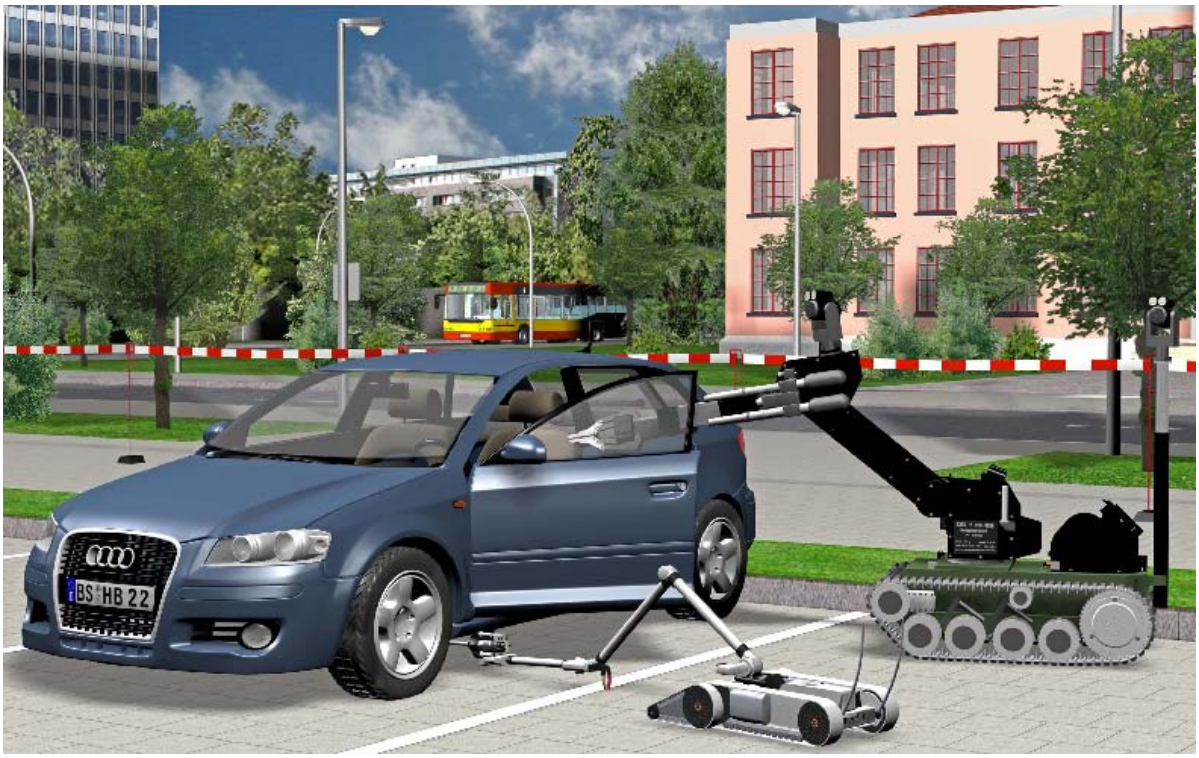

Figure 6: Robot movement simulator.

2.2.1 Scope of this Case Study

Since working efforts of the M&S developers for following the M&S development guideline and performing all documentation activities as requested in the previous case study, causes for these additional workload

should be also investigated. Thus, szenaris GmbH had to applyagain the same M&S development and documentation guidelines as well as the tailoring concept as before, while ITIS was to support these activities by means of coaching, on the one hand, and to act as external V&V agent by reviewing modeling work products and documents according the proposed V&V concepts, on the other hand. For staying within the scope and budget of this project, amount and intensity of V&V activities were limited to three of the thirteen predefined and independent scenarios.

2.2.2 Planning of V&V Efforts

At begin of the case study project, and based on the Sponsor Needs (SN), the involved three institutions by application of several tailoring actions developed a first V&V plan covering the complete M&S development cycle [1], [2], [16]. Based on the Sponsor Needs documents, including their requirement specifications and appendices, the initial version of the V&V plan was created as a cooperative effort of the project sponsor (the federal agency), the M&S developer (szenaris), and the V&V agent (ITIS). During the project, the original V&V plan was continuously refined or adapted in course of the model development process and according to the growing project experience.

Adaptions of the original V&V plan by dynamic tailoring were depending on intermediate M&S process results (work products, documantation and their V&V reviews). After development of a Structured Problem Description (SPD) simulation objectives, and detailed project requirements and constraints had been determined and specified in this product. After three iterations in this model development phase, a solid version of the V&V plan was established on basis of tailoring results.

Comprehensiveness is referred to as one of the most important quality characteristics of a V&V plan by Balci [18]. Since the" V&V Triangle" defines precise requirements for each V&V activity and structures V&V efforts in such a manner that the entire M&S development life cycle is completely covered, this concept was used to ensure the development of a comprehensive and detailed V&V plan. In addition, the execution of the V&V plan was precise, easy to execute and to manage as the "V&V Triangle" approach provides [1], [5], [6], [16]:

- Uniform and consistent documentation requirements and templates,
- An overview of all V&V phases defined for a simulation study, and
- An overview of the dependencies among V&V objectives and constraints.

Furthermore, a tailored "V&V Triangle" also visualizes tailoring results and their potential consequences. Since model development in this project used the same simulation environment (Virtools) as in the previous case study, it was already known at the beginning that complete documentation of the Formal Model (FM) were not feasible, anmd a complete work product was not available. As a consequence, the associated V&V efforts were no longer meaningful. This meant that the sub-phases 3.1, 3.2, 3.3, 4.2 and 5.3 (due to incomplete FM work product information), , as well as sub-phases 2.3and 4.5 were tailored in the context of this case study (see Figure 7).

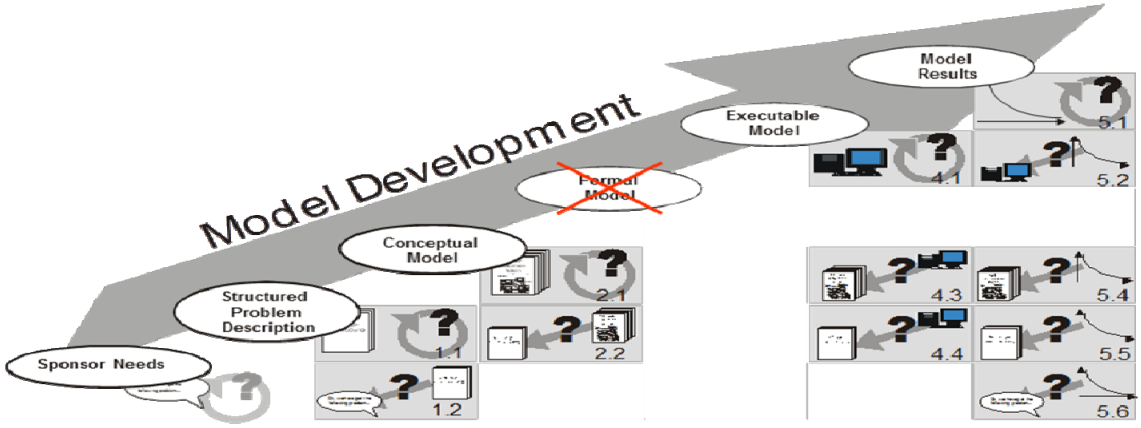

Figure 7: Tailoring consequences (tailoring on product level and subject level).

2.2.3 V&V Activities and Reports

According to the specified V&V plan, V&V efforts were applied by ITIS in parallel with model development and documentation activities performed by M&S developers (szenaris GmbH). As defined by the "V&V Triangle" approach, two kinds of V&V reviews had to be performed for each work product:

- An intrinsic, self-contained review of the associated work product (for checking completeness and consistency) versus; and
- Pairwise comparisons between work products of different development phases (for V&V of performed transformation activities).

For example, V&V of the work product Structured Problem Description began with the intrinsic examination, in which the V&V agent reviewed and evaluated the developed this work product based on the model documentation created by the M&S developer, and finally prepared a V&V report including status of this work product and – eventually – identified quality deficiencies. In the next and accordingly revised version, corrections were additionally documented in a list of changes. Since model stages, or its intermediate work products, were developed in an iterative manner, revisions with new contents were also to document in the list of changes. After final revision of this phase work product, pairwise comparison between the Structured Problem Description and the Sponsor Needs was performed. Despite six previous revisions, further 12 deficiencies were identified in this manner, and reported to model developers.

Some of the deficiencies were identified by means of the graph-based V&V approach. Since this V&V concept focuses on tracing dependencies of associated model defects along the M&S documents hierarchy, a graph structure was to be implemented. For this case study, a subset of such an M&S document hierarchy was exemplarily established as follows:

- In Sponsor Needs (SN): marking of relevant content for further investigations over the M&S work products hierarchy (such as items of requirement specifications, argumenst, assumptions, etc.);
- In Structured Problem Description (SPD): identification of corresponding consecutive issue(s) of a marked content; establishment a link to the predecessor document (here: to Sponsor Needs). If any, mark further issues, and proceed to step 3; and
- In the Conceptual Model CM): repeat iterative the prodedures of previous steps 1 and 2 until final Simulation Results (SR) and Simulation Interpretation (SI).

For M&S errors or deficiencies detection, combined application of the "V&V Triangle" approach and this graph-based V&V approach is very meaningful for revision and maintenance of M&S products. Thus, once

a new model defect is detected following this concept, model work products and documents directly or indirectly connected to this defect can be successively examined as all related defects – including predecessors and successors – are hidden, and could be traced and identified by traversing this graph structure.

In the course of this case study, detailed structure and contents requirements were determined for better documentation of a V&V plan, associated V&V activities and V&V reports as defined by the "V&V Triangle" approach. In addition, documents templates could be refined and integrated in the existing M&S- as well as V&V-process and documentation guidelines.

3.0 LESSONS LEARNED

This section presents the relevant findings obtained by the application of the four quality assurance concepts: guideline for M&S process and work product documentation, "V&V Triangle" approach, graph-based V&V, and tailoring concept. It evaluates the significance of the proposed theoretical and methodological concepts, and their practical applications in terms of efficiency and effectiveness of use. Major findings include ([1], [16]):

- The applied documentation guideline was perceived as beneficial by the project sponsor as well as by the M&S developer. For instance, in the first case study, the M&S developer determined that a legacy model component, developed in context of an earlier simulation project, should be applied to development of the Conceptual Model in this project. But for this comomponent, only black box review was feasible, and therefore V&V of the actual Formal Model was incomplete. Such issues of intellectual property rights have to be considered upfront at the begin of a project and of V&V planning.
- The documentation guideline in the form of "living documents" should be more efficient. Although the documentation efforst in the second case study were significantly reduced compared to the first case study, but still quite costly in terms of labor required for following these guidelines and documentation requirements. Based on experiences concerning the application of proposed M&S- and V&V-concepts, coaching turned out as an important and very effective effort to support novice M&S developers.
- The documentation guidelines and templates should be further developed rather than only for training simulators and preferably provided in electronic form as "living documents".
- The proposed "V&V Triangle" concept can be efficiently applied for performing management and technical activities. (According to the IEEE standard 1059 [19], a V&V effort consists of two types of tasks: management tasks and technical tasks.) While management tasks refer to activities such as planning, organizing, and monitoring of V&V efforts, technical tasks refer to quality assurance procedures, such as analyzing, evaluating, reviewing, and testing the M&S development processes and work products. In the second case study, the" V&V Triangle" was applied for planning V&V activities and for executing the examinations.
- The proposed graph-based V&V approach can be applied in combination with the "V&V Triangle". By using the V&V Triangle, model defects are usually identified individually, while the graph-based V&V focuses on tracing the dependencies of associated defects and on root cause diagnosis. The two concepts can be efficiently combined, so that a model defect is detected for the first time all of its associated side-effects can be identified and removed by means of the specific graph structure.
- Both static and dynamic tailorings are essential. Static tailoring has to be arranged at the begin of an M&S project so that all efforts of M&S development, V&V, and documentation can be determined and planned early enough. However, experiences from the two case study projects indicate that usually still a considerable amount of information, data, resources, etc. were unavailable at this stage, or certain requirements changed over time. Therefore, dynamic tailoring performed during the

M&S development process has to be considered besides static tailoring. Thus, a refined mechanism of dynamic adaptation in the course of a project was developed and integrated in the new tailoring concept.

- Special attention should be paid to the issue of intellectual property rights protection. For the V&V agent, full access to the developed model with its documentation and data is essential to conduct model, simulation and data V&V. On the other side, however, M&S developers are concerned about the possible loss of know-how and property rights, when core parts of a model designs or developments have to be available to an independent third party. An approach to solving this problem was proposed as follows:
  - The V&V agent specifies detailed V&V requirements, guidance for executing the examination criteria and measures for a key work product (or parts of it) to be evaluated,
  - An internal inspector (e.g. from the quality assurance department of a company) performs the defined examination according to the V&V specifications, and documents the process and results of each test case, and
  - The V&V agent evaluates the model being built based on the created exami- nation protocol from the developer side.
- The expenditure of model documentation and V&V reports should be considered and planned at the tendering stage of an M&S project. In order to prevent model documentation and V&V from becoming an easy prey because of time and cost pressures during project execution, sponsors should require the separate calculation of planned documentation and V&V costs in their request for proposal. Along the same line, potential contractors should give a realistic cost estimate in their project offers.

4.0 CONCLUSION

This article presents an integrated quality assurance strategy for modeling and simulation developments and applications, including several quality- and efficiency-related concepts. The guideline for model documentation enables structured and well-defined documentation throughout the entire M&S life cycle. The V&V Triangle defines a generalized concept conducting V&V in parallel with model development. The graph-based V&V, however, focuses on tracing the dependencies of associated defects using a graph structure. While the V&V attempts to detect different model defects as early as possible, the graph-based V&V approach struggles against the problem of defect propagation and offers an approach to root cause analysis. By means of the multistage tailoring, project-specific M&S, V&V, and documentation can be determined according to specified cost, time, and application constraints.

The practical experience of applying these proposed concepts is clearly positive. The documentation guideline was appreciated as an effective and sustainable approach by the development team and the project sponsor. As a consequence, the revision and further development (also “living documents”) is planned as the next step. In addition to examination of models, the V&V Triangle is also suited for developing a V&V plan. The graph-based V&V can be applied to any M&S development process, as long as the work products are well defined and structured. In addition, the graph-based V&V can be efficiently combined with the V&V Triangle. The tailoring concept was also refined to enable a more flexible dynamic tailoring within the case studies.

Since the proposed concepts were only applied to the development of training simulators in both projects, a further case study in the context of a different M&S type is intended. Furthermore, another important research for the future will concern the development of a risk-based approach to investigating M&S documentation and V&V requirements.

5.0 REFERENCES

[1] Wang Z., Lehmann A.: "Quality Assurance of Models and Simulation Applications"; In: International Journal of Modeling, Simulation and Scientific Computing, Vol. 1, No. 1, World Scientific Publishing Company, 2010.

[2] D. Brade: "Enhancing modeling and simulation accreditation by structuring verification and validation results"; In: J. Joines, R. Barton, K. Kang, P. Fishwick, Editors, Proceedings of the 2000 Winter Simulation Conference, 2000.

[3] Wang Z., Lehmann A.: "Verification and validation of simulation models and applications: a methodological approach"; In: Recent Advances in Modeling and Simulation Tools for Communication Networks and Services, Eds. Ince A. N. et al., Springer, New York, 2007.

[4] Wang Z., Lehmann A.: "A graph-based approach to verification and validation of simulation models and applications", In: Proceedings of the 22 European Simulation and Modelling Conference, Le Havre, 2008.

[5] Wang Z., Lehmann A.: "A framework for verification and validation of simulation models and applications"; In: AsiaSim 2007 – Proceedings of Asia Simulation Conference 2007, Eds. Park J. et al., Communications in Computer and Information Science, Springer-Verlag, Berlin Heidelberg, 2007.

[6] Arthur J. D., Nance R. E: "Verification and validation without independence: A recipe for failure", In: Proceedings of the 2000 Winter Simulation Conference, Orlando, 2000.

[7] Balci O., Saadi S. D.: "Proposed standard processes for certification of modeling and simulation applications", In: Proceeding of the 2002 Winter Simulation Conference, San Diego, 2002.

[8] Sargent R. G.: "Verification and validation of simulation models", In: Proceeding of the 2003 Winter Simulation Conference, New Orleans, 2003.

[9] IEEE std 1516.4-2007, IEEE Recommended Practice for Verification, Validation, and Accreditation of a Federation – An Overlay to the High Level Architecture (HLA) Federation and Execution Process (FEDEP), IEEE, 2007.

[10] Brade D., Jaquart R.: "Final state of the REVVA methodology", In: Proceedings of the 2005 Spring Simulation Interoperability Workshop, San Diego, 2005.

[11] DoD MIL-STD-3022: "Documentation of Verification, Validation, and Accreditation (VV&A) for Models and Simulations", Department of Defense, USA, 2008.

[12] The V-Modell XT 2005. Documentation Edition 1.0.1. http://www.v-modell-xt.de.

[13] Bondy J. A., Murty U. S. R.: "Graph Theory", Springer, 2008.

[14] The V-Modell XT 2009. Documentation Edition 1.3. http://www.v-modell-xt.de.

[15] Wang Z., Lehmann A., Karagkasidis A.: "A multistage approach for quality- and efficiency-related tailoring of modeling and simulation processes"; In: Simulation News Europe 19 (2): 12-20, 2009.

[16] Wang Z., Kißner H., Siems M.: "Applying a documentation guideline for verification and validation of simulation models and applications: An industrial case study", In: Proceedings of the 7th Industrial Simulation Conference, Loughborough, 2008.

[17] Virtools 2008. http://www.virtools.com.

[18] Balci O., Nance R. E., Arther J. D., Ormsby W. F.: "Expanding our horizons in verification, validation, and accreditation research and practice", In: Proceedings of the 2002 Winter Simulation Conference, San Diego, 2002.

[19] IEEE std 1059-1993, IEEE Guideline for Software Verification and Validation Plans, IEEE, 1993.

[20] SISO-GUIDE-GM-VV-001.1-2012; SISO-GUIDE-GM-VV-001.2-2013; SISO-GUIDE-GM-VV-001.3-2013; SISO (Simulation Interoperability Standardization Organization), 2012 – 2013.