Software Development for Medical Devices

Overcoming the Challenges of Compliance, Quality and Cost

An MKS White Paper
Software Development for Medical Devices

Introduction

Software is fast becoming the differentiator for manufacturers of medical devices. The rewards available from software innovation are balanced by the risks and challenges of regulation, stringent quality requirements, market pressures, and significant complexity. Balancing these competing interests requires tailored application lifecycle management that addresses the unique needs of medical devices companies.

Medical Devices Defined

"Any instrument, appliance, material…, including the software necessary for its proper application, intended by the manufacturer to be used for human beings for the purpose of… diagnosis, prevention, monitoring, treatment or alleviation of disease…"

ISO 13485, Quality systems – Medical devices – Particular requirements for the application of ISO 9001

Medical device software

- Software used as component of a medical device
- Software that is a medical device
- Software used in the production of a device
- Software used to manufacture a device
- Software used in the implementation of the quality system

General Principles of Software Validation; Final Guidance for Industry and FDA Staff, Jan 2002.

Software can serve as a source of innovation and a key differentiator for medical devices, especially given the adaptability of software and the speed at which software changes can be prototyped and implemented. Software is also becoming more voluminous and complex, which creates significant risk.

To complicate matters even more, software components used in medical devices fall under regulatory scrutiny. Two prominent regulatory bodies include the FDA for medical device products marketed in the U.S. and the European Medical Device Directive for medical device products marketed in the European Union.

FDA - Food and Drug Administration – CFR 21 Part 11 & Part 820

The U.S. Code of Federal Regulations (CFR), including 21 CFR Part 11, Electronic Records and Electronic Signatures and 21 CFR Part 820 Quality System (QS) Regulations (as well as ISO 1385 specifications) defines a number of practices and processes which must apply to the development of software that acts as a component of a medical device or is used to aid in the production or manufacturing of a device.

MDD - European Medical Device Directive 93/42/EEC

The Medical Device Directive is a harmonized European standard which protects against the risks associated with the design, manufacturing and packaging of medical devices. Compliance with the requirements of the Medical Devices Directive is declared by placing the CE marking on the product, and supplying the device with a Declaration of Conformity. Conformity requires a series of assessments and examinations of the quality system and examination of the product type and design dossier relating to the product.

In addition to market specific regulatory requirements such as the FDA 21 CFR 820 and European Union Medical Device Directive, ISO 13485 provides an overarching ISO standard for quality management systems; equally ISO 14971 focuses on risk management systems. Implementing each of these ISO standards and attaining certification can help expose greater global market opportunities and make it easier to satisfy the market specific regulatory requirements.

Regulatory pressures and increasing complexity, coupled with the increasing globalization of the market, creates an environment where quality, reliability and safety compete with the business needs to reduce time-to-market and increase product development efficiency.
This paper reviews some of the key challenges facing the medical device industry, and examines the role that an application lifecycle management (ALM) platform can play in meeting these challenges.

### Top Software Challenges in the Medical Device Industry

1. **Compliance**
   - a. Management of Documentation and Records
   - b. Identification and Traceability
   - c. Document Control and Change Management
   - d. Managing Risk

2. **Device and Software Quality**
   - a. Growing Volume of Software and Product Variants puts Quality at Risk
   - b. Cost and Consequences of Recalls

3. **Cycle Time and Cost**
   - a. Increasing Market Demand and Competition
   - b. Coordination Across Groups (Internal and Suppliers)

### Compliance

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<thead>
<tr>
<th>Challenge</th>
<th>ALM Solution</th>
<th>Benefits</th>
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| Management of Documentation and Records | • All documentation can be stored and versioned with appropriate access controls.  
                                          | • Automatically generate DHF reports                                          | • Reduce effort to create DHF from weeks to minutes                     |
| Identification and Traceability         | • Unique identification of each document and asset                          | • Significant time savings                                               |
| Document controls and Change Management | • Automated workflow for effective process enforcement  
                                          | • Powerful change control automatically documents all allowed changes       | • Automated and enforced processes  
                                          | • Named trace relationships between all assets                              | • Full change history without overhead                                      |
| Managing Risk and Reducing Recalls      | • Simplified electronic tracking of requirements, risks and mitigations with relationships and dependencies  
                                          | • Automatically compute Risk Priority Number (RPN)                        | • Reduced risk  
                                          | • Automated support for Y-model with named relationships between requirements, design, and software assets and their associated verification and validation assets | • Improve productivity while maintaining compliance and managing risk      |

1. For the purposes of this paper, we mean ‘traceability reports’ to refer to any and all reports needed to establish a complete record of the status, change history and interrelationships among the software assets for a medical device. This includes but is not limited to reports such as a Device Master Record or a Design History File/Device History Record and also includes generation of needed documentation such as a traceability matrix or detailed change histories and audit trails for any individual asset or workflow.

### Management of Documentation and Records

**Key Challenge:** Massive volume of documentation is difficult to manage and reduces team productivity.

**Solution Summary:** Consolidate storage of all documentation in a system that supports electronic signatures.
Throughout the product lifecycle, a significant amount of documentation and records is required by both manufacturer and regulator in order to demonstrate thorough design controls, document controls and audit history. In the design and development phase, regulatory requirements such as CFR 820 Subpart C titled Design Controls specifies that a “manufacturer shall establish and maintain procedures to ensure that the design requirements relating to a device are appropriate and address the intended use of the device...”. The European Medical Device Directive provides similar guidance that “the application must describe the design, manufacture and performances of the product in question...”. Further advice is also provided under both regulatory bodies on steps to be taken for reviewing designs, verifying and validating designs, the FDA specifies the retention of a design history (DHF) file to record all design change history, while the MDD specifies a similar technical file package to document testing data, risk analysis, requirements and cross-reference with any change documentation.

These detailed records, requirements specifications and design documents are commonly maintained through the use of Microsoft Office tools or some form of issue tracking tool, in order to prioritize and manage change records. This approach makes it difficult to keep all of this disparate data accurately synchronized. Collaboration by email or sharing documents on network drives is also inefficient, often resulting in inconsistencies or untimely communication.

To solve these challenges requires consolidation of key product documentation in one coherent ALM platform, with change control over all assets. In addition, the platform that stores these documents and records needs to auditably capture asset history. Finally, the storage of electronic signatures on records or changes is often required by regulatory bodies (for example US Federal CFR 21 Part 11).

**Identification and Traceability**

**Key Challenge:** Creating and maintaining trace relationships between records is arduous and time consuming.

**Solution Summary:** Simple, automated trace management and reporting.

In addition to the storage of documentation and records, the identification and traceability of relationships between those artifacts is also important. Traceability ensures that individual assets like requirements, design specifications or software code can be traced through the entire product development lifecycle (including connection to any needed corrective or preventive action that might arise). Achieving this traceability can be overwhelming to manage manually even for a single medical device – it can result in traces across hundreds of documents. Managing these traces across disparate toolsets and repositories can require person-weeks of effort and can result in human error or omissions.

To minimize the overhead in this process, capturing all assets in a coherent ALM platform permits automation that ensures that each document and the individual elements of a document or software component has a system-generated unique identifier. As users then decompose requirements into more detailed technical requirements, specifications and software components, they can establish trace relationships using these unique identifiers.

Automated trace reporting from within a single ALM platform can also aid in the identification of missing traces and highlight areas of concern. This ability also means that traceability matrices from the product documentation set can be generated with mouse-clicks instead of person-weeks.

**Document Controls and Change Management**

**Key Challenge:** Cost effective change management and capture of change history.

**Solution Summary:** One coherent platform with automated change control and workflow support.

With any product lifecycle, change is inevitable. In a highly regulated environment, it is critical that all aspects of change are documented and auditably captured. To effectively track changes, it is important to have a method of tracing the change to the specific affected requirement. This traceability is best served by requirements documented in a shared repository, with clear identifiers that distinguish between requirements.
A requirements change process can be similar to a coding change or defect tracking process. We first need to describe the change and the scope, and then the change needs to follow a defined process which involves review and authorization. Change records should be reviewed by a change review board or project team which has the necessary skills to evaluate the importance of the change and the cost or impact of implementing it.

As change is implemented, it is critical to auditably identify what change occurred, both within the documentation and within the software. A coherent ALM platform addresses this need by providing process and workflow controls which support the recording, prioritization and review of change records, with complete traceability to the documentation and software artifacts affected. These change records can then be reported on and automatically included in history files and change reports to satisfy regulatory reporting requirements.

**Managing Risk Exposure and Reducing Recalls**

**Key Challenge:** Tracking risk with associated preventive and corrective actions is a large burden, especially if tracking is manual.

**Solution Summary:** Automated FMEA support integrated with change management.

Product defects are less expensive to fix if they’re found early in the development process. In the medical devices market, product recalls can impact not only product profitability, but can affect the overall corporate brand. To mitigate this risk, organizations must implement best practices that identify preventive measures and take corrective action. This need places an additional burden on traceability.

Preventive action is the practice of determining potential product faults and taking proactive measures in order to reduce the likelihood of occurrence. FMEA (failure modes and effect analysis) is one approach to implementing support for preventative action. FMEA provides an analytical approach to potential failure modes and their associated causes. When considering possible failures in a design – which can impact safety, cost, performance, quality and reliability – an engineer can get a lot of information about how to alter the development/manufacturing process, in order to avoid these failures. FMEA provides an effective tool to determine which element presents the greatest risk based on priority or severity, and therefore which action is needed to prevent a problem before it arises. An adaptable data model is therefore required to be able to effectively capture these risks, prioritize them and trace them to their preventive or correction action. The same model must contain evidence demonstrating that the risk has been mitigated.

Corrective action is required in order to respond to a variety of real-world events and conditions, including non-conformance, audit issues as well as customer / patient reported complaints. When a complaint or other issue is captured, it should automatically trigger an appropriate workflow to communicate that concern to reviewers who are responsible for taking further action. This capability needs to be tightly integrated with the change management process and is best addressed by managing all of the assets and activities in a single ALM platform.

**Device and Software Quality**

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| Growing Volume of Software and Product Variants puts Quality at Risk | • Reuse of key engineering assets including requirements, code and test cases  
• Traceability links across projects and products to measure the true cost of defects and change requests | • Ability to perform impact analysis  
• Measure the costs of defects and ensure resolution across the product line |
| Cost and Consequences of Recalls | • Traceability to Corrective Action and Preventive Action  
• Impact analysis capabilities to identify impact across the product line | • Minimize the recurrence of defects  
More quickly identify the overall impact and cost of complaints or adverse events |
Growing Volume of Software and Product Variants puts Quality at Risk

**Key Challenge:** Dealing with the complexity of software products and product lines.

**Solution Summary:** Reuse capabilities and traceability provide greater understanding of complex software products and the dependencies or impact of change across the product line (leading to better quality and less rework/error).

The introduction of more advanced medical device technology such as products with additional monitoring technology means that the volume of software as an overall part of medical devices is increasing. The introduction of software into the medical devices industry creates added complexity. Design documentation and change management practices are not limited to hardware components. The challenge with software is its inherent nature to be reused. As reusable software modules or components are developed for so called “utility functions”, the cost of tracking where that software is used increases. This reuse and increased complexity can be difficult to manage and if it is not managed well, the quality and reliability of the software is put at risk.

Software Product Lines and variant management become key concepts to support the complexity of multi product line software development. The benefit to an organization in formally adopting a software product lines methodology is in the economies of scale, for the reuse of requirements, design specs and source code. However, these reuse practices also require sophisticated practices and process for managing reuse and for dealing with software defects across the product lines. Change management and defect management process needs to support the categorization by product line for accurate measurement of the true cost of change and complaints.

Using an ALM platform to manage the software development and documentation for medical devices is the ideal path for companies that wish to leverage the software product lines approach. Greater reuse and modularization of software lead to greater efficiency, shorter cycle times and more consistent software quality.

Cost and Consequences of Recalls

**Key Challenge:** Timely assessment of non-conformity to assess impact, resolution and to protect brand.

**Solution Summary:** Impact analysis capabilities are critical to identifying the overall impact of non-conformity, the true cost and scope of an issue, and its root cause.

How well a company manages regulatory non-conformity matters can have significant effect on the future success of the product, the extent of the company's liability (or financial loss) in the event of significant problems, as well as the value of a company's brand and reputation.

To reach a recall decision, careful analysis and evaluation of adverse-event reports and identification of specific products or product lots is required. Impact analysis capabilities are a must in order to truly identify the revisions of software that may be affected by a defect and to understand how far reaching a software defect may be. Traceability is another key factor in being able to demonstrate that the necessary Corrective and Preventive Action (CAPA) plan has been put in place and the necessary root-cause analysis has been conducted.

A company's success in interacting with regulators and communicating with health-care professionals, the media, and its own employees can have a major impact on future perceptions of the company as well as possible liability. It is also important to determine whether a device failure occurred and to identify and correct its cause in order to get that product back on the market after a recall, to recoup the product investment to date.

If all product documentation and software is stored in a coherent ALM platform, not only will it be less likely that non-conformity observations/citations be issued (because regulatory reporting has been consistent and accurate) but the time and effort required to respond to non-conformity is drastically reduced. This translates into more rapid and more accurate responses, which can mitigate the potential risk and damage of non-conformity.
Cycle Time & Cost

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| Increasing Market Demand and Competition | • Process improvement  
• Streamlined process  
• Electronic signature and approvals process  
• Automated compliance reporting | • Simplify areas of process, encourage lean and agile practices where appropriate  
• Automate compliance reporting as a byproduct of the process |
| Coordination Across Groups     | • Geographically distributed development and communication  
• Capability to import and export data for seamless interchange  
• Process automation and enforcement | • Improved internal communication  
• Improved external communication |

**Increasing Market Demand and Competition**

**Key Challenge:** Launching innovative products and remaining competitive in a global market.

**Solution Summary:** Automation of process to streamline the amount of time it takes to attain premarket approval and get product to market.

For medical device companies, there is a constant need to balance agility with compliance and quality. Larger companies can be at a disadvantage in remaining competitive as a greater number of smaller niche players are introduced into the market. Regardless of company size, innovation must be encouraged but not at the cost of compliance and quality issues which could hinder brand credibility. Growth in the medical device industries is estimated at 6% annually with market demand rising.

Of interest to medical device companies is how they can automate the internal approvals of pre-market approval paperwork and ensure that regulatory submissions happen on a timely basis and are thorough enough to pass the stringent quality regulations in place. Management of software and documentation in a coherent ALM platform means that internal processes will not become bottlenecks in the relations with these agencies, thereby preserving the time-to-market for new and updated medical device products. This is equally important for smaller organizations bringing their first device to market as well as larger firms with multiple product lines.

**Coordination Across Groups (internal and suppliers)**

**Key Challenge:** Leveraging a global network of resources and suppliers.

**Solution Summary:** Collaboration capabilities that provide real time notification across disparate, geographically distributed teams and capabilities for importing/exporting data for suppliers.

Many parties are involved in the development, launch and maintenance of innovative medical device products. Large medical device companies may structure themselves internally to take advantage of geographically distributed resources, maximizing the amount of development that occurs over a 24-hour period. Additionally, communication with suppliers is constant to ensure supply chain dependencies are understood.

Support for geographically distributed teams must include effective communication and traceability across geographical and cultural boundaries. This ensures common processes are adhered to and traceability and compliance documentation can easily be generated regardless of who may be involved in the engineering process.
Communication with external suppliers should be simplified through emerging technology standards such as RIF (Requirements Interchange Format) to allow requirements documents and specifications to be seamlessly shared between suppliers and OEMs. These standards evolved out of the automotive industry but through the adoption of XML make it possible for all sorts of product companies to produce documentation that is more easily shared, reducing turnaround times for change requests and defects.

Any solution deployed to manage requirements, documentation, source code and other assets across a distributed development organization must enable accurate and consistent collaboration among disparate stakeholders. The ideal solution here is an ALM platform that has the adaptability to address the functional and technology requirements of those disparate stakeholders, while seamlessly scaling across the enterprise.

Conclusion

Given that software is represents both the greatest opportunity for innovation and competitiveness as well as one of the greatest challenges in terms of risk, complexity and regulation, medical device organizations must take control of their software development with appropriate technology solutions.

The reality is that the complexity and pace of change for embedded software is rapidly outpacing the ability of organizations to address these issues with manual processes and disconnected point tools. The only way to mitigate risk while priming the organization for continuous innovation is through the consolidation of all software assets and activities into a single, unified solution. Only in a unified solution will medical device organizations get the end-to-end traceability that is needed for success, while avoiding the problems, errors and delays that are generated by ‘best of breed’ solutions.

About MKS

Founded in 1984, MKS is the enterprise application lifecycle management (ALM) company, enabling organizations to industrialize software engineering and achieve continuous innovation. Our customers are able to tame the complexity of today’s complex and critical software, reducing cycle times and mitigating risk at every stage of development. Our software engineering platform, MKS Integrity, is the only unified platform that offers the depth and breadth of capability to deliver collaboration and control over all development assets and activities. Our rapidly deployable solutions scale from 10 to 10,000 users across one or many roles, they integrate easily with adjacent and legacy systems, and they are repeatedly proven in successful deployments by demanding global enterprises.

MKS offers tailored solutions for the needs of medical devices organizations. These solutions have been proven in successful implementations by leading medical device manufacturers worldwide. For more information, visit our website at www.mks.com/medicaldevices.