**SUMMARY OF: P910023/S355, P030054/S284, P030035/S133, P970013/S064, P880086/S255, P880006/S093**

**ENDURITY CORE DEVICES/ST. JUDE MEDICAL**

## EXECUTIVE SUMMARY/BACKGROUND

St. Jude Medical has submitted this 180Day PMA Supplement to request approval for the **Endurity Core Pacemakers** SR and DR, Models PM1152 and PM2152 respectively, **Endurity Core Firmware** Unity 2.7, Model 3330 **Merlin Patient Care System (PCS) Programmer** version 20.1.1 software, **MerlinConduct** v1.3, **MerlinReflect v1.3**, and updated **Merlin Electronic Health Record (EHR) DirectExport** connectivity.

The new Endurity Core family of single (SR) and dual (DR) chamber pacemakers are based on Endurity family of SR/DR pacemakers (P88086/S230, approved March 20, 2014). The new pacemakers will be programmer with an updated firmware, Unity 2.7. This new device and firmware will provide a new set of features.

The Endurity Core devices are programmed with the Merlin 20.1.1 PCS. Version 20.1.1 software update for the PCS Programmer provides an update to the programmer to provide support for the new devices as well as the addition of new features.

MerlinConduct (MC) is a mobile application that allows for control of the programmer through an Apple iPad, limited to use within several meters of the programmer. MC has been updated to v1.3 in order to address minor defects, incorporate functional enhancements, and provide support for Apple iOS 8.

Merlin EHR DirectExport is a new feature that enables networking capabilities on the Merlin PCS programmer via an interface with Merlin.net. Once connected, Merlin.net receives automatic transfer of Merlin PCS programmer session records from the programmer via a secure network. The firm is requesting approval for use of four networking devices to enable this new feature.

Over the course of the review, the review team identified 6 major deficiencies. These included concerns relating to software documentation, labeling, device testing, and EMC. These deficiencies were sent to the firm in a letter dated April 28, 2015. The firm responded to these concerns on May 18, 2015. The firm adequately addressed the concerns included in the April 28th letter, answering the remaining questions regarding the safety and effectiveness of the device. For this specific PMA supplement, the reviewer recommends approval.

## DEVICE AND CHANGE DESCRIPTION

**Endurity Core Pacemakers**

The Endurity Core devices are low voltage imputable pulse generator devices based on Endurity family of SR/DR pacemakers.

The Unity Firmware has been updated to support a new set of features. The devices will provide the following capabilities.

1. Unity 2.7 Firmware
2. Auto Lead Polarity Detection (ALPD)
3. Sensor Driven Rate Response Functionality

The following functions will not be available in the Endurity Core models.

1. EGM Storage capacity of 14 min (reduced to 2 minutes);
2. CorVue Thoracic Impedance Monitoring;
3. Atrial ACap Confirm capture threshold monitoring and trending;
4. Max Tracking Rate > 180 bpm;
5. SenseAbility Technology;
6. Exercise Compliance Trends;
7. Capture/Sense Test Morphology; and
8. Remote Monitoring Support (except for MerlinOnDemand in hospital support).

The header design for each model contains standard IS-1 bores (1 for SR, 2 for DR).

**Endurity Core Firmware**

The Endurity Core family of pacemaker devices uses Unity 2.7 firmware. The Unity 2.7 firmware is based on Unity 2.5 firmware (approved March 20, 2014 under P910023/S311). The update to Unity 2.7 provides new set of features for the Endurity Core family of pacemakers. Cybersecurity has been addressed in this update in accordance with FDA's guidance "Guidance for the Content of Premarket Submissions for Management of Cybersecurity in Medical Devices."

**Merlin PCS Programmer**

The Merlin PCS programmer is a portable, dedicated programming system designed to interrogate, program, display data, and test St. Jude Medical implantable devices. The intended use remains the same as approved in P030054/S008 (October 12, 2005).

The programmer software is being updated to v20.1.1 in order to add the following features:

1. Support the new Endurity Core devices
2. Address Cybersecurity in accordance with FDA guidance
3. Implement MerlinReflect, a mobile application that allows for remote viewing of the programmer screen
4. Support new version of MerlinConduct v1.3
5. Implement Auto VectSelect in the programming of LV quadripolar leads
6. Provide automated transfer of programmer session to Merlin.net

Item 6 was previously possible only by the user manually uploading the data following a session. The automated transfer will provide easier access to session records. There are no manufacturing or hardware changes requested as a result of the proposed software changes.

**MerlinConduct**
MerlinConduct (MC) is a mobile application that allows for control of the programmer through an Apple iPad, limited to use within several meters of the programmer. MC has been updated to v1.3 in order to address minor defects, incorporate functional enhancements, address Cybersecurity concerns, and provide support for Apple iOS 8. The intended use remains the same as approved in P910023/S297 (approved April 10, 2014).

The mobile app allows the clinician to more closely interact with the patient and other medical staff while also being able to view and manipulate the programmer screen using the iPad. The connection is made between the MC and the Merlin PCS programmer via a secure peer-to-peer Wifi connection (the devices connect directly with each other). The direct wireless connection limits the connection to several meters. The Wifi security protocol encrypts the data with an (b) (4) that also performs error checking on each packet of data sent to ensure the integrity of transmitted data. The Merlin PCS generates a random, (b) (4) key for each connected iPad-Merlin PCS programmer pair. Therefore, only the MC mobile app can send/receive data with the programmer. The Merlin PCS SSID is not broadcast, adding another layer of security.

During an MC session, the Merlin PCS programmer monitors the Quality of Service (QoS) of the wireless connection with the MC mobile app. When QoS drops below a threshold, screen sharing and control will end on the iPad. Any ongoing tests initiated from the iPad will be canceled and the device will be returned to programmed device settings. If pacing system analyzer tests are ongoing when the connection is dropped, the Merlin PCS programmer will initiate VVI pacing at a high output voltage to ensure continuous pacing support.

**Merlin Electronic Health Records DirectExport**
Merlin EHR DirectExport is a feature that enables networking capabilities on the Merlin PCS programmer via an interface with Merlin.net. Once connected, Merlin.net receives automatic transfer of Merlin PCS programmer session records from the programmer via a secure network. The firm is requesting approval for use of four networking devices.

**INDICATIONS FOR USE**
The indications for use of the Endurity Core family of pacemakers are identical to those approved in the Endurity family of pacemaker devices.

Implantation of a single-chamber pulse generator or dual-chamber pulse generator is indicated in one or more of the following permanent conditions:

- Syncope
- Presyncope
- Fatigue
- Disorientation due to arrhythmia/bradycardia
- Or combination of those symptoms

Rate-Modulated Pacing is indicated for patients with chronotropic incompetence, and for those who would benefit from increased stimulation rates concurrent with physical activity.

Dual-Chamber Pacing (Dual-chamber pulse generators) is indicated for those patients exhibiting:

- Sick sinus syndrome
- Chronic, symptomatic second- and third-degree AV block
- Recurrent Adams-Stokes syndrome
- Symptomatic bilateral bundle branch block when tachyarrhythmia and other causes have been ruled out.

Atrial Pacing is indicated for patients with sinus node dysfunction and normal AV and intraventricular conduction systems.

Ventricular Pacing is indicated for patients with significant bradycardia and:

- Normal sinus rhythm with only rare episodes of A-V block or sinus arrest
- Chronic atrial fibrillation
- Severe physical disability

*LEAD REVIEWER COMMENTS: The sponsor stated that the indications for use are identical to the FDA approved Endurity family of devices.*

## SUMMARY OF CLINICAL AND NON-CLINICAL DATA

To support PMA supplement approval, the firm has submitted comprehensive bench testing and animal study testing. No clinical testing was provided.

**Endurity Core Pacemakers**

- Comprehensive bench testing
    - Risk Assessment
    - Biocompatibility
    - Sterilization
    - Packaging and Shelf Life
    - Mechanical/Electrical (DVT)

**Endurity Core Firmware**

- Comprehensive bench testing
    - Risk Assessment
    - System Testing
    - Level of Concern
    - Software Description
    - Device Hazard Analysis
    - Software Requirements Specification (SRS)
    - Architecture Design Chart
    - Software Design Specification (SDS)
    - Traceability Analysis

    - Software Development Environment Description
    - Verification and Validation Documentation
    - Revision Level History
    - Unresolved Anomalies
    - EMC Testing
    - EAS Testing

**Merlin PCS Programmer**

- Comprehensive bench testing
    - Risk Assessment
    - System Testing
    - Level of Concern
    - Software Description
    - Device Hazard Analysis
    - Software Requirements Specification (SRS)
    - Architecture Design Chart
    - Software Design Specification (SDS)
    - Traceability Analysis
    - Software Development Environment Description
    - Verification and Validation Documentation
    - Revision Level History
    - Unresolved Anomalies

**MerlinConduct**

- Comprehensive bench testing
    - Risk Assessment
    - System Testing
    - Level of Concern
    - Software Description
    - Device Hazard Analysis
    - Software Requirements Specification (SRS)
    - Architecture Design Chart
    - Software Design Specification (SDS)
    - Traceability Analysis
    - Software Development Environment Description
    - Verification and Validation Documentation
    - Revision Level History
    - Unresolved Anomalies

**MerlinReflect**

- Comprehensive bench testing
    - Risk Assessment
    - System Testing
    - Level of Concern
    - Software Description
    - Device Hazard Analysis
    - Software Requirements Specification (SRS)
    - Architecture Design Chart
    - Software Design Specification (SDS)

- Traceability Analysis
- Software Development Environment Description
- Verification and Validation Documentation
- Revision Level History
- Unresolved Anomalies

**Merlin Electronic Health Records Connectivity**

- Risk Assessment
- System Requirement Specification
- System Verification Report
- EMC Testing
- Wireless Coexistence Testing

**Endurity Core Pacemakers, Endurity Core Firmware, and Merlin PCS Programmer**

- Comprehensive animal study testing

## CLINICAL STUDY OVERVIEW

No clinical study was performed. Basic device performance remains unchanged. An expert clinical reviewer reviewed this and agreed that no clinical study was necessary.

## ENDURITY CORE PACEMAKERS AND UNITY 2.7 FIRMWARE REVIEW

### LABELING REVIEW

The firm provided proposed labels for the Endurity Core Pacemakers as well as clean and redlined versions of the User's Manual. A review of the labeling identified concerns regarding confusing identification for the device. These concerns were included as a major deficiency to the firm in the April 28th letter. The firm responded on May 18 and again on July 15 addressing these concerns. The firm's response adequately addressed the remaining concerns regarding the labeling.

### RISK ANALYSIS REVIEW

The firm provided a risk assessment in the submission. It is based on previous risk assessments performed on prior devices including the Endurity family of pacemakers, upon which the Endurity Core pacemakers are based. Existing control measures were verified to be implemented and effective. All risks were defined according to the firm's risk evaluation matrix by mapping each risk according to the probability and severity ratings. The firm also included a cybersecurity risk assessment for the Endurity Core device.

The risk assessment identified no unacceptable risks. After evaluating the totality of the identified risks, it was determined that overall residual risk is acceptable, and the sponsor states that no new risks were introduced as a result of the risk control measures. No risk to benefit analysis was performed. Overall, the firm provided adequate risk analysis.

A system risk assessment was provided for the Endurity Core product family (Endurity Core devices and Unity 2.7 firmware). The identified risks related mostly to the new

Auto Lead Polarity Detection. Identified risks were appropriately mitigated. All risks associated with the system were evaluated and have been deemed acceptable.

**ENGINEERING AND MANUFACTURING REVIEW**

The firm provided schematics for the proposed Endurity Core hybrid as well as drawings for the header and device assembly including comparisons to the predecessor. The device hardware included minor modifications. The firm included manufacturing process information as compared to the approved Endurity devices. The material was reviewed by the lead reviewer and found acceptable.

**BIOCOMPATILITY REVIEW**

The firm provided a Biocompatibility Certification stating that additional biocompatibility testing is not needed as identical materials are already utilized in the market approved devices. This material was reviewed by the lead reviewer and found acceptable.

**STERILIZATION, PACKAGING, AND SHELF LIFE REVIEW**

The sterilization, packaging, and shelf life review was performed by the lead reviewer. The firm provided the protocols and test results for two separate sterilization methods proposed for the Endurity Core pacemakers. This testing was performed to ensure the proposed devices could be adopted into the firm's existing sterilization cycles. The test criteria were evaluated per an internal standard. The firm compared the proposed devices design effects to a worst case product design for ethylene oxide (EO) sterilization. (b) (4) [redacted] The firm leveraged existing bioburden testing, arguing that the materials of the device are identical to that used in a similar legally marketed device produced by the firm, which has undergone bioburden and EO/EC residual testing. Also, the proposed devices use the same sterile barrier system and packaging processes as currently approved pacemaker devices. Lastly, the firm states that the load configuration for sterilization will be the same as that used for other pacemakers. No further testing was performed on the proposed device. The proposed shelf life for Endurity Core devices is 24 months, which is identical to the shelf life of the predecessor device. Testing on this packaging meets the requirements of ISO11607 Part 1, Section 6.4. The reviewer found the testing performed on the proposed device to be adequate. Also, the firm's leveraging of testing performed on devices with identical materials and similar manufacturing processes to be appropriate in this context.

**DEVICE VERIFICATION AND VALIDATION**

The firm provided device verification and validation results in the submission. The firm states that all test procedures were executed successfully and that no issues were found during test execution. The proposed device has only minor hardware modifications as compared to the predecessor device. The verification and validation testing included hybrid design verification, header dimensional testing, spring verification, connector insertion and electrical isolation testing, electrical device testing, mechanical device

testing, EMC testing, electronic article surveillance testing, battery longevity testing, and general safety testing. The device verification and validation testing was reviewed by the lead reviewer with the exception of the EMC testing and electronic article surveillance testing, which was reviewed by an expert reviewer. During the review, minor questions were raised regarding the testing conducted on the proposed device. These were answered interactively by the sponsor. A deficiency was included in the April 28 letter regarding the longevity estimates of the device. The firm responded on May 18 adequately addressing the concerns of the reviewer. The reviewers found the device verification and validation testing for the Endurity Core device to be adequate.

**ENDURITY CORE FIRMWARE TESTING**

The firm provided the informational elements outlined in the Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices, Section 3 (FDA, CDRH, issued May 29, 1998). This included the required elements for software with a Major Level of Concern. This material was reviewed by the lead reviewer and documented. The reviewer found information provided to be adequate.

## MERLIN 20.1.1 PCS PROGRAMMER REVIEW

**LABELING REVIEW**

The firm provided proposed labeling for the Merlin PCS Programmer v20.1.1 as well as clean and redlined versions of the User's Manual. This was reviewed by the lead reviewer. The updates to the manual consisted mostly of new information relating to the updated features of the Endurity Core pacemakers as well as the new Auto VectSelect feature on the programmer itself. The reviewer found the labeling of the programmer to be adequate.

**RISK ANALYSIS REVIEW**

The firm provided a risk assessment for the programmer update as well as the programmer and device system in the submission. This material was reviewed by the lead reviewer. The risk analysis is based on previous risk assessments performed on previous iterations of the programmer software. Existing control measures were verified to be implemented and effective. The firm also identified ongoing risk control measures. All risks were defined according to the firm's risk evaluation matrix by mapping each risk according to the probability and severity ratings. This risk evaluation included risks related to cybersecurity of the Merlin PCS programmer. The cybersecurity risk assessment considered threats to confidentiality, integrity, and availability. Control measures were added wherever possible to reduce the security risk rating. The reviewer found the risk benefit analysis performed for any identified risks to be appropriate and found the risk analysis to be adequate.

**MERLIN PCS 20.1.1 SOFTWARE TESTING**

The firm provided the informational elements outlined in the Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices, Section 3 (FDA, CDRH, issued May 29, 1998). This included the required elements for software with a

Major Level of Concern. This material was reviewed by the lead reviewer and documented. The reviewer initially found the information provided for MerlinReflect to be lacking and communicated this to the firm in the April 28 deficiency letter. The firm responded to this concern on May 18 and provided the necessary information for the mobile app. The reviewer found the information provided to be adequate for the Merlin PCS programmer and supporting mobile app.

### MERLIN PCS 20.1.1 AND UNITY 2.7 SYSTEMS VERIFICATION AND VALIDATION

The firm provided a system verification and validation report for the Merlin PCS and Endurity Core system. This information was reviewed by the lead reviewer. This included verification and validation testing for the new features on the Merlin PCS programmer as well as its interface with Endurity Core and other legally marketed implantable devices. Clinically relevant scenarios were created that focus on the use of the system, with an emphasis on patient safety, proper functionality of the feature set, consistency of data, and performance of the system. The reviewer found the provided testing to be adequate.

### ANIMAL STUDY

The firm conducted an animal study, including study design and results in Appendix 21.5. This was reviewed by an expert reviewer. This acute GLP canine study was submitted to evaluate performance of Merlin software 20.0.2 and to evaluate Assurity/Endurity family of devices with the updated firmware. Pre-defined acceptance criteria were established for each study objective which involved in demonstration of software features, ability to pace and sense cardiac muscle, and ease of device handling and implant. All study objectives were met. The reviewer found the testing adequate and has no further concern.

## MERLINCONDUCT 1.3 MOBILE APPLCIATION REVIEW

### LABELING REVIEW

There are no labeling changes reported for MerlinConduct v1.3. The firm provided screen shots of the programmer and iPad where instructions are provided to the user. This guides the user through the process of connecting the iPad to the Merlin PCS programmer.

### RISK ANALYSIS REVIEW

The firm provided a risk assessment for the MerlinConduct mobile app. This information was reviewed by the lead reviewer. All risks were defined according to the firm's risk evaluation matrix by mapping each risk according to the probability and severity ratings. All identified risks were classified as acceptable by the firm. The firm included a description of ongoing risk control measures including a formal periodic review of complaints and returns data for the family of pacemakers no more than every 2 years from date of product launch. The firm also included a separate cybersecurity risk assessment that considered the intentional or unintentional cybersecurity threat. The firm considered threats to confidentiality, integrity, and availability. Each potential threat

scenario was given a security risk rating based on an Ability to Exploit and harm rating. Control measures were added wherever possible to reduce the security risk rating. The reviewer found the provided information to be adequate.

**MERLINCONDUCT 1.3 SOFTWARE TESTING**
The firm provided the informational elements outlined in the Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices, Section 3 (FDA, CDRH, issued May 29, 1998). This included the required elements for software with a Major Level of Concern. This material was reviewed by the lead reviewer and documented. The reviewer initially found the information provided for the update policy of MerlinConduct to be lacking and communicated this to the firm in the April 28 deficiency letter. The firm responded to this concern on May 18 and provided the necessary information for the mobile app. The reviewer found the information provided to be adequate for the MerlinConduct mobile app.

## MERLIN ELECTRONIC HEALTH RECORDS CONNECTIVITY

**LABELING REVIEW**
The firm provided proposed labeling for the Merlin EHR DirectExport network adaptors as well as the User's Manual. This information was reviewed by the lead reviewer and found to be adequate.

**EMC TESTING**
The firm provided EMC testing for the proposed network adapters to provide network connectivity to the Merlin PCS programmer. This was reviewed by an expert reviewer. The reviewer had questions about test setup and the results of the tests. This was communicated to the firm in the April 28 letter. The firm responded to this deficiency on May 18. The reviewer reviewed their response and found it adequate.

**WIRELESS COEXISTENCE TESTING**
The firm provided wireless coexistence testing for the proposed network adapters to provide network connectivity to the Merlin PCS programmer. This was reviewed by an expert reviewer. The reviewer identified deficiencies in the information provided. This was communicated to the firm in the April 28 letter. The firm responded to this deficiency on May 18. The reviewer reviewed their response and found it adequate.

**RISK ANALYSIS REVIEW**
The firm provided a risk assessment for the Merlin EHR. It provides the risks associated with the connectivity of the Merlin PCS programmer with Merlin.net. All risks were defined according to the firm's risk evaluation matrix by mapping each risk according to the probability and severity ratings. All risks were classified as acceptable. This information was reviewed by the lead reviewer and found to be adequate.

**MERLIN EHR DIRECTEXPORT SYSTEM REQUIREMENTS SPECIFICATION**

The firm provided an outline for the System Requirement Specification for the Merlin EHR DirectExport. It defines the product and provides system requirements necessary for the connectivity of the programmer with Merlin.net. This information was reviewed by the lead reviewer and found to be adequate.

**MERLIN EHR DIRECTEXPORT SYSTEM VERIFICATION TESTING**

The firm provided a System Verification Report. The report verifies Merlin PCS programmer connectivity conforms to the design inputs. This considers clinically relevant scenarios that focus on the use of the system, with an emphasis on patient safety, proper functionality of the feature set, consistency of data, and performance of the system. Testing was performed on a Merlin PCS programmer, network accessory, and programmer software representative of final submitted versions. This information was reviewed by the lead reviewer and found to be adequate.

**CONCLUSION AND RECOMMENDATION:**
**Recommendation: Approval**

During the review, 6 major deficiencies were noted by the review team. The firm responded to each of the deficiencies addressing all outstanding concerns. For this specific PMA supplement, the reviewer recommends Approval.