AMPS-QT

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AMPS-QT is a quarterly journal dedicated to all the people and organizations involved in the world of cardiac safety. Published by AMPS LLC, it covers all aspects of methodology and software technology related to clinical trials and Thorough QT studies.

Editorial

Since its inception the AMPS mission, as stated on our web site, has been to design and provide ad-hoc state-of-the-art technology through understanding and sharing of the customers' requirements and expectations. Throughout its history AMPS has worked and cooperated with almost all the key players of the cardiac safety industry, including federal agencies, large hospitals, and several academic institutions. The result is an impressive collection of tools that covers pretty much the full spectrum, from resting ECGs to, more recently, continuous ECG recordings. We believe the time is ripe to provide our readers with a comprehensive overview of what we have accomplished in over 15 years of activity, and allowed AMPS to become the leader in this market. The best candidate for the task is of course our well-known Chief Scientist Fabio Badilini PhD. F.A.C.C., whom most of our readers probably personally know or have met in a capacity or another at a conference, as he has been the key mind at the core of the design of each and every one of the AMPS tools. One of the key traits of Fabio, for those of you who know him, is to be too modest, even to this day, to admit he has played a pivotal role in shaping and defining the way ECG traces are analyzed by the large majority of this industry as of today. Luckily enough the American College of Cardiology reminded him how important his contribution has been by awarding him the Honorary Fellowship back in 2009. Please enjoy his summary and don't hesitate to contact us at support@amps-llc.com should you wish to learn more about any of the tools. Our customer support engineering team will be happy to schedule a Webex conference to illustrate to you the full potential of our technologies.

AMPS Views on:

Fifteen years

By Fabio Badilini, AMPS llc.

It is with a bit of nostalgia that I often think back to the early days of AMPS. It was the year 2000 and it is somehow amazing to think through the different milestones and achievements and realize that we have been around for fifteen years. It is not one of those feelings one gets as he gets older, but just a consideration that being a small and totally independent company (and wanting to stay so), was maybe an ambitious mission that we at AMPS are proud to have so far achieved.

Interestingly, but not surprisingly, the two software products we started from are still there and remain two cornerstones of our production and financial revenue. I'm talking of course of CalECG and ECGScan.

CalECG, our solution for the measurement of resting ECGs, was initially released (v1) as an on-screen caliper application designed to annotate 10 seconds resting ECGs from paper-scanned images. Starting with v2 (launched in 2003), full management of digital ECGs from different formats was included, including automated measurements from AMPS proprietary algorithm (**BRAVO**). Today (the latest released version is 3.7.0), CalECG is a rather sophisticated package used by many customers which, in addition to offering an extensive measuring platform with a

modern user interface, can also be used as a black-box to perform different tasks. For example, taking advantage of the multiple input/output formats supported, CalECG can be used as a converter from one ECG format to another (which is sold as the **Mizar product**), or simply as a generator of reports or waveform images (**CSPER**, more later). CalECG is COM compliant meaning that it exposes a rich set of APIs that allows other COM aware applications to take full control.

ECGScan is the world-recognized solution for digitizing paper ECGs. To be very honest, we never thought its need could last for so long. In fact, the first released version had a rather basic user interface and did not include features to optimize execution time (as opposed to the currently released version 3.3.0). We were obviously wrong, since paper ECGs are still widely used in 2015!!! And while we are always extremely adamant in recommending the usage of digital ECGs whenever possible, warning against the fact that digitizing a printed ECG causes a huge amount of information (more than 80%) to be thrown away forever, we still get many requests, and it is difficult to predict when paper ECG storage (or even worse analysis) will disappear for good. Of note, ECGScan is the only tool that, in addition to being available for standard licensing, is also optionally available as a service by AMPS.

FDA ECG Suite. Right after the introduction of the HL7 XML standard used for the digital submission of ECGs to the FDA warehouse, AMPS released a specific standalone product, the FDA ECG Suite, aimed to offer a platform to perform a set of tasks on HL7 ECG records. These modules include a viewer, a validator and a scoring component. Rather than operating on a single ECG, this specific product is oriented to the quality assessment of ensembles of ECGs, either from an actual study or from any collection. For this reason, in addition to core centers, the FDA ECG Suite has also been used directly by sponsors and in some case by non-pharma clinical organizations that needed to verify the quality of a specific component of their workflow such as, for instance, the accuracy of leads hook-up of a given acquisition site and/or hospital division. The modularity of the Suite allows all the possible combinations of the different components (for example one could only be interested in the validator or in the viewer, or the combinations of the two). The scoring module is rather sophisticated and includes all sort of quality criteria, going from noise content and complexity (analytical scores) and metrics related to specific measurements (parametric scores).

BRAVO. While not being per-se a product, BRAVO is almost *everywhere*. It is in CalECG, providing automated measurements and computation of de-novo representative beats and it is in both in Fat-QT and FDA ECG Suite, providing all the infrastructure to compute the quality scores. As part of an internal AMPS project, we are currently assessing the accuracy of standard measurements from BRAVO (PR/QRS/QT intervals) on a set of ECGs that have been blindly annotated by seven independent readers. Results of this internal project will be made available to customers and will eventually be considered for publication.

ECG Viewers (and more). One of the primary AMPS missions is to offer smart flexible and customizable tools while keeping a structured and easy-to-maintain software platform. This vision has never been more challenged than with ECG viewers. Each player in the industry has different ideas on what the ideal viewer should look like and how it should operate; as a result, through the years, we have received multiple requests that were virtually impossible to meet with a single application. Today AMPS offers a variety of viewers that can be essentially grouped into two categories:

a) *Standalone viewers.* These are applications installed on a local machine. There are two options with different features (and price..). The low end solution is **ViewerLight,** the viewer-only version of the FDA ECG Suite, that only allows the display of a single HL7 ECG at a time. The second and more complete tool is **ViewECG,** compatible with all ECG formats and capable of handling the simultaneous management of multiple records (eventually all the ECGs in a study) with flexible and optimized browsing features through a tree-based interface.

b) *Web-based viewers*. These viewers allow the display of ECG waveforms within a client-server environment. We started with **Ariel**, available since 2003, an ActiveX component that includes an API library to virtually control all the features of the standalone viewer. As all ActiveX controls, Ariel depends on Microsoft COM technology and works best only under Internet Explorer. Knowing that the COM technology will soon become obsolete, we began development of two alternative options aimed at providing web-based solutions viable on most platforms. The first one is **CSPER (short for Command line Suite for Processing ECG Recordings)**, a black-box that can be installed on a server and that performs a series of tasks such as the generation of multiple graphical display of the same ECG. CSPER can be script-controlled and can be easily programmed to repeatedly execute the same set of tasks on a large number of ECGs. For example, one could generate a set of different images (single lead, 3x4, overlapped median beats, and so on) to be embedded into a web-page. The actual design of the page that hosts the ECG images can be handled by the customer or, upon request, with service support from AMPS. This solution is very practical and does not limit the resolution of the ECG waveforms displayed and at the same time it preserves the source code performing the graphical display, which remains embedded in the black box executable code. Once used, the graphic images can be discarded as they can be re-generated anytime using the digital ECG record. The second solution (not yet released) is a 100% HTML5 ECG viewer that will run on both Windows and tablet Oss (Android and iPhone).

Fat-QT (short for Fully Automated QT). This product, initially presented in AMPS-QT Issue 5, reflects AMPS philosophy with respect to the fully or highly-automated ECG analysis. We believe that there is not really "a" best way of doing things. As it is often the case, it depends. With some study protocols with certain type of cohorts and target analysis a fully automated approach may be ideal; in others, the need of supervision of all data by an expert cardiologist may be required. Fat-QT allows a hybrid model proving a powerful way to classify ECGs according to customizable quality criteria. For example, a set of ECGs could be divided into three groups (buckets): ECGs with very good quality tracings, ECGs with 'some' level of noise, and ECGs with high noise content. Depending on the type of measurements on the table, the three buckets may follow a different workflow; for example, the ECGs in the bucket with high noise content may be discarded (not measured), those with moderate noise reviewed by a cardiologist and those in the good bucket measured automatically. Of course this is just one basic example of tailored editing and of course the criteria (number of buckets and parameters/scores used for the classification) can be made more sophisticated. For example, the bucket with ECGs requiring cardiologist review could include ECG with noise, slow/fast heart rates, ECGs with presence of arrhythmias, ECGs with flat or low-amplitude T waves and so on.

In this issue we limited the overview to AMPS products applicable to the short-duration scenario. In fact, all the mentioned products are based on ECGs from a few seconds up to a few minutes of duration. For continuous ECG (Holter, telemetry and others) AMPS developed a bank of dedicated applications which will be described in another dedicated issue of AMPS-QT. Of course, you can contact us anytime for more information. Last, but not least, here below we provide a list of references where components of AMPS products have been used.

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Products News

Looking forward
In Q3 of 2015 AMPS is planning to release:

- The first version of ABILE algorithm for beat detection and arrhythmia assessment for Continuous ECG Recordings.
- A new version of CER-S, using the new ABILE algorithm, including the following platforms:
  - Continuous ECG beat detection and classification
  - ECG beat editor
  - Arrhythmia detection and Arrhythmia editor
- A new version of our 12-leads measuring algorithm, BRAVO, taking advantage of the benchmark study we have performed between Q4 2014 and Q2 2015.
- A new version of CalECG, Fat-QT and TrialPerfect with the latest version of BRAVO algorithm.

AMPS Notebook

Fabio attended the 40th **ISCE Conference**, held in San Jose, CA on April 2015.
Fabio will be present at the **Computing in Cardiology** Conference that will be held in Nice, France from September 6th to 9th, 2015.
In Nice Fabio, together with other industry players, will be involved in an open round table to discuss the future of the PDF-ECG, covered in AMPS-QT Issue 23 with the editorial of Dr Roberto Sassi from the University of Milan. AMPS is one of the pioneer promoters and will continue to support this initiative; we will soon start to support PDF-ECG within our product line. Look for more news and updates on the next issue of AMPS-QT.

To conclude this issue, a picture taken at AMPS office in Montichiari where two special guests visited us:
The Drews!