The need for a specialization of Electrical Engineers in the area of Avionics was already recognized in 1976 by prof. van Oosterom from the Faculty of Aerospace Engineering at Delft University of Technology (at that time still TH Delft). To address the identified need, in 1979 the Faculty of Electrical Engineering started a special program which aimed to educate interested students with a background in Electrical Engineering in the area of Avionics. At present, it is an interfaculty specialization profile. Although having been restructured several times in the past 30 years, the core philosophy of the program remains the same:

• Use a set of coherent courses from the Faculty of Aerospace Engineering and the Faculty of Electrical Engineering to provide the students with the background needed to successfully perform an M.Sc. research project in the area of Avionics.
• Focus the Avionics research on a number of internationally recognized challenges and pursue them through international cooperation.
• Maintain a state-of-the-art research infrastructure to provide an inspiring learning and research environment.

The frequent reception of best-student paper awards at the largest international Avionics conference (organized jointly by IEEE and AIAA) and the contribution of many former EWI Avionics students in highly visible international research programs (such as the NASA Aviation Safety Program) prove that this approach is very successful. To provide EWI students that are fascinated by aviation a better idea of how they can obtain the required background for a future career in the field of Avionics, this article starts with a brief overview of today’s challenges. Using examples from previous and current international research projects, it is illustrated how M.Sc. and Ph.D. students and researchers from EWI have contributed to defining the future state-of-the-art in Avionics.
Avionics refers to Electronic systems used in Aviation, and the word itself is a blend of Aviation and Electronics. Avionics are not only essential for today’s commercial and military aircraft to fly, but also enable their integration into the overall traffic management system. For safety critical applications such as navigation, aviation imposes requirements and constraints on the electronics system which are far more stringent than for example in the consumer electronics domain. This has an impact on the design of the Avionics.

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Innovation in aviation
When comparing a Boeing 747 that was built in 1969 with a Boeing 747 built in 2010, the biggest leap in capabilities can be attributed to Avionics. Engines have become far more efficient through the use of Fully Autonomous Digital Engine Control (FADEC). Safety has increased through the introduction of the Enhanced Ground Proximity Warning System (EGPWS) and the Traffic alert and Collision Avoidance System (TCAS). Through better integration and automation, the number of crew members that is required to operate the aircraft has been reduced to two. The instrument Landing System (ILS) provides the capability to land under zero visibility conditions, and the Flight Management System (FMS) allows fuel optimized path to be flown.

Indeed, in the past 40 years, a large part of the innovation in the aviation domain was the result of developments in the area of Avionics.

The reason for this leap is that for Avionics the enablers lie in the electronics domain and hence many capabilities advance with the speed of Moore’s law. Also today, the challenge for Avionics is to benefit from this advantage when addressing the issues aviation is confronted with.

The following four issues are internationally regarded as top priorities:

1. Reduction in the environmental burden caused by aviation
2. Further increase in safety, both in the air and on the airport
3. Further increase in airport availability (independent of the actual weather)
4. Integration of unmanned aircraft into controlled airspace

Environment: There is still ample potential of Avionics to reduce the burden of Aviation on the environment. The theme of the IEEE/AIAA 2010 Digital Avionics Systems Conference (DASC) is ‘Greening Aviation’. Whereas today’s instrument landing system only
provides guidance for straight-in approaches, future Avionics systems, enabled by more accurate and reliable sensors, will support precision guidance along curved paths. This provides the opportunity to circumvent noise sensitive areas that lie below the current approach paths. Through optimized navigation in the vertical dimension, the current transitions between level and descending path segments during an approach can be minimized or even eliminated, allowing a significant reduction in the required engine thrust and thus reducing emissions. To safely fly these more complex approaches, advanced cockpit displays are required to provide the pilot with the information needed to assess whether the aircraft stays free of any hazards.

Safety: During the past thirty years, the major improvements in the safety of commercial aviation were achieved through the extrapolation of sensor-based information. To reduce midair collisions, TCAS interrogates the transponders on board of other aircraft to determine whether there is a collision hazard. Likewise, GPWS uses data from the radar altimeter to determine whether the aircraft inadvertently is getting close to the terrain. In the past ten years, the developments in the area of compact data storage have allowed GPWS to be augmented with a warning system that relies on the use of a worldwide terrain database and GPS-based position information. These databases can also serve to provide the pilot with a synthetic view of the environment, independent of visibility conditions. Before actual operational credit can be taken for this capability, a concept is needed that timely detects hazardous discrepancies between the database and the real world.

Availability: Whereas large airports such as Schiphol are equipped with guidance systems that allow properly equipped aircraft to land under zero visibility conditions, many smaller airports do not have such equipment. Reasons comprise cost of the required infrastructure but also location. In a mountainous environment, today’s ILS cannot be deployed because of undesired signal reflections. A navigation system that meets or exceeds the accuracy, continuity and integrity requirements of today’s [ground-based] ILS without requiring significant infrastructure on the ground is one of the top priorities for Avionics research.

Unmanned aircraft: Recent guidance from the U.S. Federal Aviation Administration (FAA) suggests that self separation needs to be a component of an Unmanned Aircraft System (UAS) Sense and Avoid solution in order for UAS to behave similarly to manned aircraft. Conceptually, UAS self separation is the protective [or conflict avoidance] method that precludes a threat aircraft from ever triggering a time-critical collision avoidance maneuver. To realize such a self-separation capability requires an Avionics system comprising sensors to detect the collision hazards, algorithms to filter out observation noise and compute solutions for those threats that are identified as real ones, and user interface concepts to allow an operator to monitor the situation.

Avionics research @EWI

Within the EWI Avionics research program, specific challenges related to the aforementioned issues are being addressed. To benefit from similarities between the different challenges, the research is structured along common themes such as integrity, path optimization and human machine interfaces. The expertise at EWI covers hardware, software, algorithms, user-interfaces and system interfaces, allowing the multidisciplinary challenges that are typical for Avionics to be properly addressed. The EWI Avionics research has an excellent reputation on an international level. In 1998 the Faculty of Electrical Engineering (EE) was invited by industry to join them in an effort to compete for research in the context of the NASA Aviation Safety Program. As part of a team lead by Avionics manufacturer Rockwell Collins, synthetic vision system prototypes were developed, integrated and first flight tested in 2000. Based on the results, Avionics researchers from EWI further refined these prototypes and in 2001 the resulting system was success-
fully evaluated in the NASA Boeing 757 during the Eagle-Vail flight tests (figure 2). In August and September 2001 more than 100 continuous descending curved approaches were flown in a terrain challenged environment.

One of the Avionics students that became involved in the research in 1999 during his M.Sc. project stayed on as a part-time researcher and was one of the three engineers that Rockwell Collins allocated to support this NASA flight-test program. For the contribution to the overall NASA Aviation Safety program the Turning Goals Into Reality Award was received.

The system test flown in 2001 relied on the use of a digital terrain database to provide the pilot with information about the terrain hazards. The Achilles-heel of any database-oriented system is that errors in the database can cause terrain hazards present in the flight path of the aircraft not to be depicted. To enable timely detection of hazardous discrepancies between the real environment and the synthetic environment, the prototype system was extended with the capability to integrate a real-time sensor images. In 2004, four EWI Avionics researchers participated in the NASA flighttests during which this system was evaluated (figure 3).

As indicated earlier, part of the focus is on unmanned systems. Several Avionics students performed their research in this area on topics such as automatic landing systems, air-space integration and the use of networks to achieve control from geographically separated locations. Prototypes of UAV mission management stations developed in a joint project between EWI and the Royal Netherlands Naval College are used by the Royal Netherlands Air Force to explore new concepts of operation using mission level simulations.

The amount of rewards that has been received indicates that the quality of both the M.Sc. projects and the overall research is internationally recognized. In 2005, M.Sc. student de Vries received the IEEE/AIAA Best Student Paper Award at the DASC for his Avionics research project. The following year, M.Sc. student ‘t Hart received this award for his M.Sc. project that focused on UAV control. In the past five years, the Avionics research was awarded with a total of fourteen international awards, two of which (in 2007 and 2008) were ‘Best of Conference’.

Avionics education @EWI

The EWI Avionics program prepares interested students with the background required to become an Avionics Engineer. This involves both courses such as ET4138 which focus on the Avionics systems and courses at Aerospace Engineering dealing with aircraft performance (AE4-220ET) and flight dynamics (AE3-302)

The Avionics program is supported through an excellent research infrastructure. Room 20.320 on the 20th floor houses a research UAV operator station with which new concepts for mission management can be evaluated. Room 20.070 houses a research flight deck, equipped with a programmable Electronic Flight Instrument System, a Flight Management System, simulation of all required sensor systems, and a projection system to simulate the view out of the cockpit (figure 1). This flightdeck is used both for research projects and in the avionics education program (ET4244).

Avionics is a fascinating area and quite frequently students that became involved with a particular topic during their M.Sc. project continued to work in this area. Some during a subsequent PhD research project, some as a researcher at EWI or another University such as Ohio, and others at institutes such as NLR, organisations such as LVNL and companies such as ADSE and Rockwell Collins.

If you are a student at EWI and fascinated by aviation, you should certainly consider the opportunity to become an Avionics engineer. EWI provides an excellent Avionics education program that prepares you for a future where you can successfully compete with the best of the best.