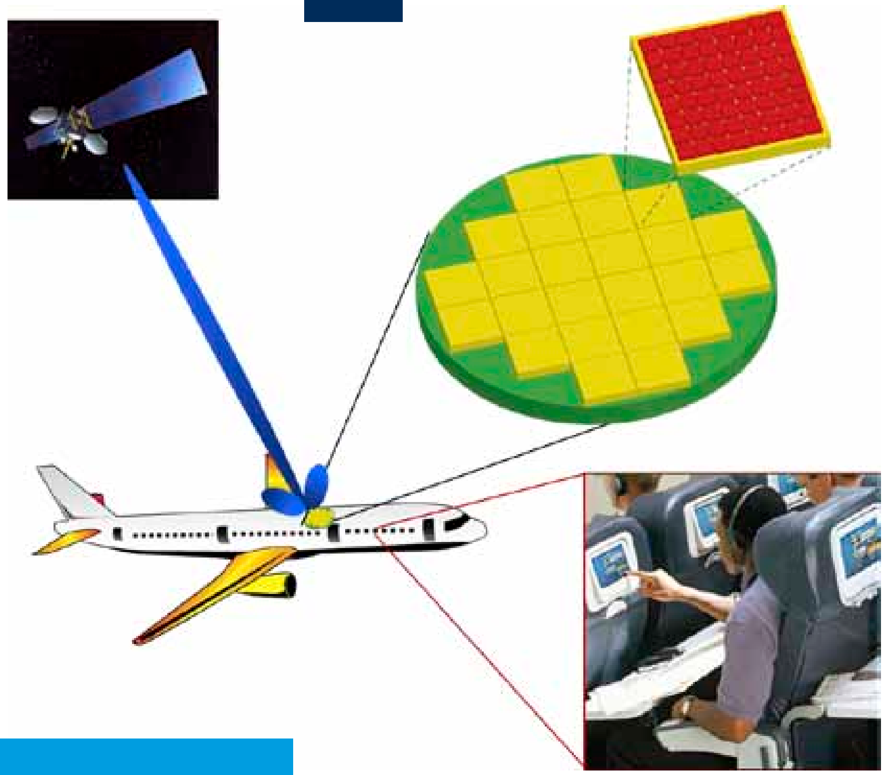
NL Agency
Ministry of Economic Affairs



Project number: IPD12009
Project name: Photonic and RF Integration of Optical Beamforming Modules in Smart Antennas for Today (Promis2Day)
Goal: to produce an integrated optical beamforming module for an antenna array to be used in nautical and avionics satellite communication

High-speed broadband connectivity on an aircraft through satellite communication using an ultra flat antenna module

Photonic chip for *fast satellite communication*

To realise broadband connectivity on board commercial aircraft, trains or ships, a satellite antenna is required that can steer itself toward the signal source. The existing dish-based solutions are obviously unsuitable for use on moving vehicles, and the flat antenna systems currently on the market have several drawbacks as well. By developing a novel photonic chip, the IOP project 'Promis2Day' will produce a prototype of an ultra flat antenna module that will be smaller, more intelligent and less expensive to produce.

"Consumers expect high-speed broadband connectivity anywhere, any time," says Chris Roeloffzen, a researcher at the University of Twente and project leader of the IOP project 'Promis2Day'. "Yet whenever we board a plane, ship or train, live TV and fast Internet access are out of our reach. The main inhibitor is the lack of an ultra flat antenna system that can be built into the vehicle's roof for accurate satellite tracking."

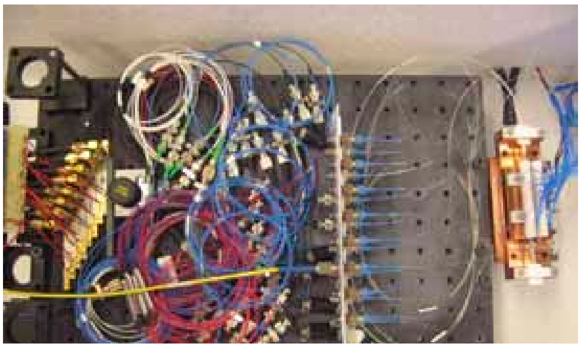
"The international response to this revolutionary technique has been very positive, but further integration is required to realise a cost-efficient and compact module"

Beamforming

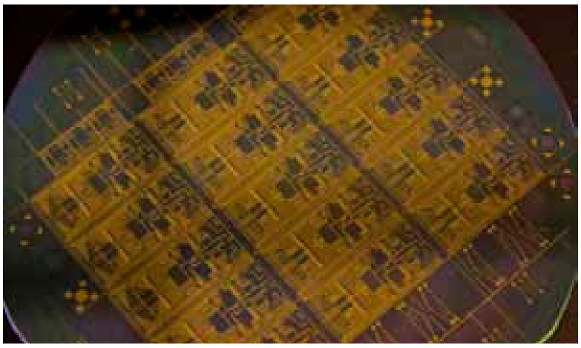
Existing flat antenna systems consist of multiple antenna elements arranged in a neat, rectangular grid. These elements can receive and amplify radio signals from a particular direction, while suppressing signals from other, unwanted directions. This is possible by means of beamforming techniques. "But if the signals from the satellite reach the surface of the antenna elements diagonally rather than at a right angle, they will be out of phase when they reach the beamformer located behind the antennas," explains Roeloffzen. "This results in a signal with poor quality, since those signals cancel each other out."
Until recently, there were two ways to correct this problem: using directed-beam antennas or using a phase shifter-based beamformer. Directed-beam antennas are directed mechanically towards the signal source. But mechanical components always come with maintenance issues and are rather big. To avoid using them, flat phased-array antennas are used to electronically steer or 'shift' the beam. These antennas, too, have a disadvantage: correcting the phase differences with a phase shifter reduces the strength of the signal for different frequencies, resulting in insufficient bandwidth. "On top of that, neither type of system is still flat enough to be built directly into the fuselage of an aircraft. Instead, they are mounted on top of the aircraft inside a protective radar dome or 'radome'."

Penalty loops

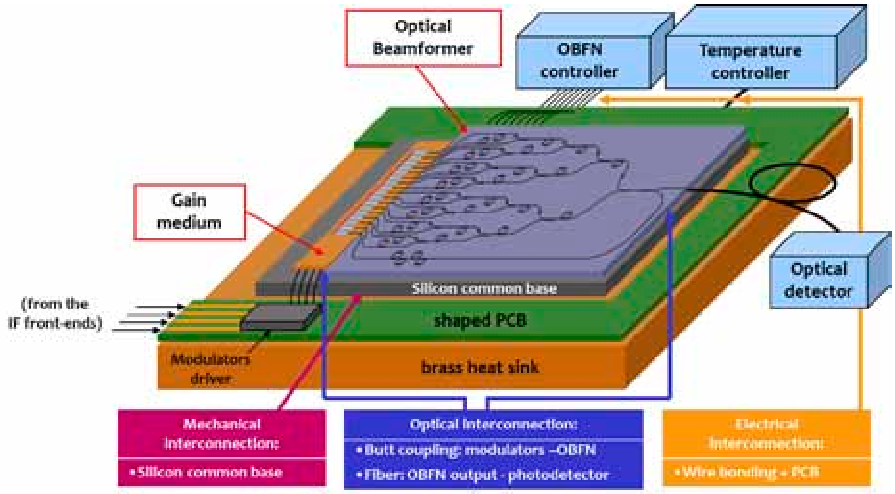
In earlier projects, researchers at the University of Twente developed a demonstrator for a new type of antenna system that cancels out these drawbacks. This system can not only track satellites during the flight of the aircraft without any mechanical movement but is also smaller, cheaper to produce and more intelligent. Last but not least, it is more environmentally friendly because it is ultra flat. "Because of the radome, the current systems consume significantly more kerosene. Since the aerodynamic drag of a flat antenna system is zero, that can save an aircraft approximately 2 to 3% on fuel consumption compared to other systems for airborne satellite communications."
The demonstrator of the special antenna, which was developed and successfully tested by Roeloffzen's Telecommunication Engineering group, contains an Optical Beam Forming Network (OBFN) as its core technology. Roeloffzen explains: "In the OBFN, the high-frequency radio signals are first converted into optical signals so they can be processed. Then we delay these light signals by making the signal path longer or shorter, as necessary, using optical ring resonators. In these resonators, the light signals can be made to do additional 'penalty loops' to delay their arrival." This functionality is integrated on a single photonic chip using regular CMOS production techniques. Finally, the resulting signal is converted back to radio-frequency



The existing demonstrator, containing an older version of the optical chip (right) and off-the-shelf components with bulky glass-fibre cables (left). 'Promis2Day' will integrate all these components on a single photonic chip



Wafer containing the current version of the photonic chip (Photo: LioniX)



The design of the integrated optical beamforming system

signals. "The international response to this revolutionary technique has been very positive, but further integration is required to realise a cost-efficient and compact module. We want to get all the necessary steps onto a single chip. For instance, the converters we are using in the current demonstrator are expensive, off-the-shelf components with bulky glass-fibre cables. Our aim is to reduce the size of the demonstrator from 30 x 40cm to a tile the size of a beer coaster containing 64 elements. Ultimately, one antenna system will consist of 32 such tiles and will be able to establish a satellite broadband connection with a speed of 3 Gb/s. That is the maximum speed that current satellites offer."

Market potential

Roeloffzen's group is responsible for the system architecture in this project. His researchers are working closely together with the Laser Physics and Nonlinear Optics group, also of the University of Twente, which will design and optimise the necessary laser and converters. Several industrial partners are involved as well. The university's spin-off company LioniX will design and produce the optical chips using their TriPleX optical waveguide technology. This technology can process the light signals on the chip with minimal energy loss. Neways Micro Electronics is responsible for developing the packaging. Last but not least, SATRAX, another spin-off of the university, will commercialise the resulting smart antenna array. "I am convinced that there is great market potential for this solution," says Roeloffzen. "That is why I founded SATRAX in 2009. Airlines, producers of antenna systems and ultimately the automotive market all want to offer broadband connectivity to their customers. But to be able to do that, it is essential to miniaturise the components on a single optical chip and to lower the costs significantly. In this project, we will prove that this can be done."

Participants:

- LioniX
- Neways Micro Electronics
- SATRAX
- University of Twente

Contact:
Dr ir Chris Roeloffzen
T: +31 (0)53 489 28 04
E: c.g.h.roeloffzen@utwente.nl