

Welcome to Antennas
workshop 2022

Your expectations (1/2)

1. “Get deeper knowledge in antenna design.”
2. “Antenna design, fabrication, and test.”
3. “I expect that I will learn and understand more about different antennas and how they behave.”
4. “My expectation is to learn the steps of antenna design process from theory and simulations to measurements. I also hope that the students can affect on what kind of antennas they design during the course.”
5. “I hope that on this course I would study how to think as an antenna designer, based not only on some strict specifications, but also on the reliability, economical expediency and some general aims (e.g., antenna to solve general task, not concrete one)”

Your expectations (2/2)

6. “I expect to learn the antenna design methodologies, simulations options and testing techniques. Furthermore, I would like to learn the best practices while working on microwave projects and systems.
7. “I wish to finally learn how to actually design an antenna. I want to learn more about the little things that the books might not cover. I also want to learn more about CST.”
8. “Here are some things that came to my mind, I think these would aid at least my learning and competence. I understand if these cannot be covered though, my proposals are tailored to my learning interests.

Antenna element design: Various complex antenna element analysis (starting from simple structures and adding various modifications to them) and for example relating the current vectors (field plots) to the radiation patterns. Some mode analyses would also be great.

Antenna arrays: Design and/or analysis of different decoupling structures by first observing the currents in/on the array. Also if possible and the time permits, some grating lobe mitigation methods could be studied.”

Students' feedback from earlier years

"Overall, this course was fun and interesting. It improved my knowledge about different antenna designs and gave me a stronger understanding of basics and even some more advanced theory. It gave me more experience on CAD modelling, which is always useful. It was a challenging course but not too challenging. It took a bit more time than I would have liked to invest in. I will definitely recommend this course for anybody that is even slightly interested in antennas and antenna design." (2021)

"One of most interesting and educational course in my studies in Aalto. Teaching was excellent, I liked the approach that students were independent, with reading and finding the specific information from the articles. Teachers were giving the overall guidelines and were there to help if needed. These course combines the theory to practice in a pleasant way." (2021)

"This was a great course. The two different parts provided two very different challenges. The first one was an easier problem with more degrees of freedom, while the second one was much more challenging with seemingly very limited possibilities. This course has improved my knowledge of simulations and prototyping. Additionally, I was able to refresh my knowledge and learn more about different types of antenna measurements. Having to report my progress made me spend more time on processing and understanding the results. All in all, I found that this course was a nearly perfect balance between theory and practice and also individual and guided work." (2021)

"Very well-organized course. The way, how the individual results was written down was very good style to do it and the lectures were also very good. The weekly discussion about results was very good way to handle the results. I learn a lot in this course, in specially in practice but I also learnt about antenna design and theory. This was probably the best organized course, where I have participated." (2019)

The course consists of two practical antenna design tasks in Periods 1 and 2

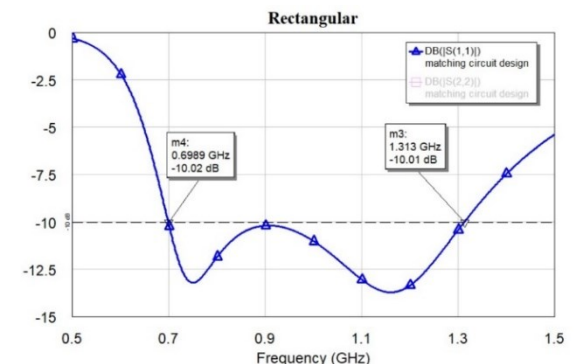
- In both topics,
 - an antenna is designed, manufactured and finally measured, the findings are introduced and discussed in the final seminar
 - there is possibility for variable challenge/antenna type (basic, intermediate, top level)
 - teachers provide the goals and support, but they do not provide step-by-step instructions – i.e., students are encouraged for planning and executing their work

1. Antenna array for 1.5-GHz radar (Period 1)

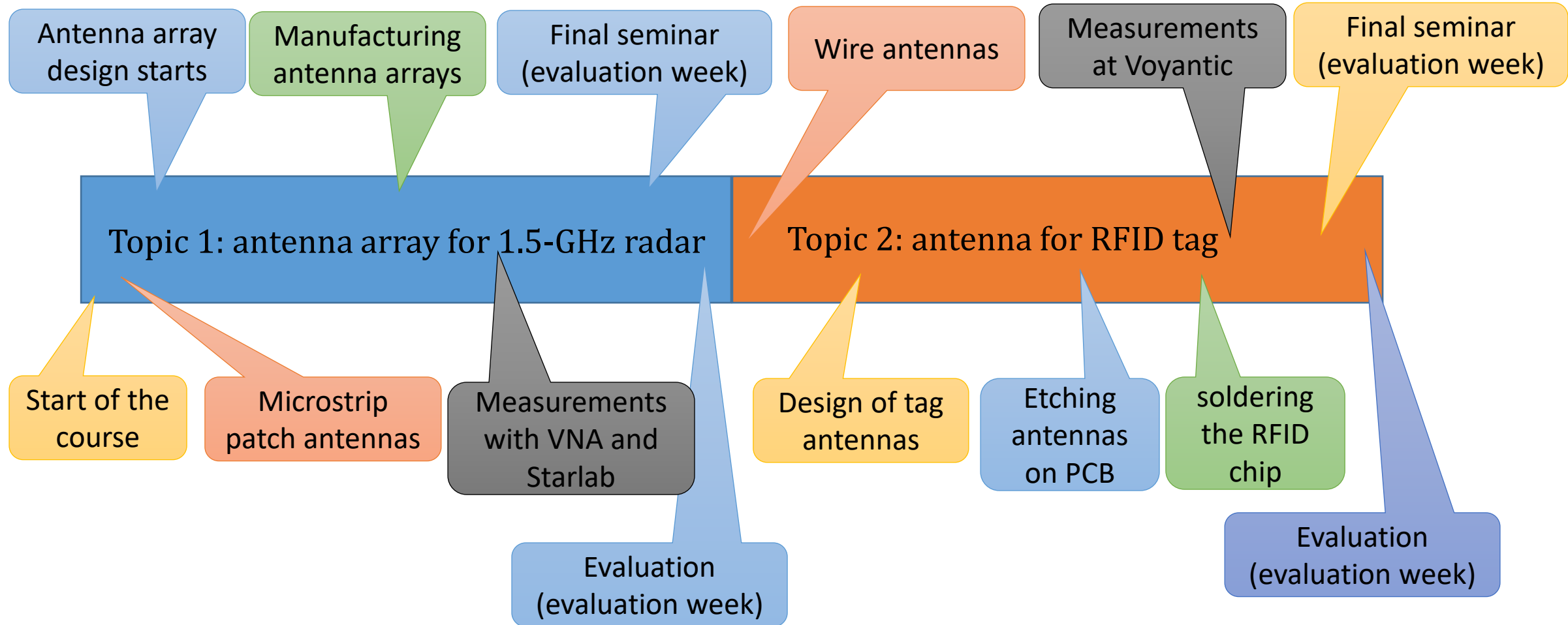
- Antenna arrays is a vital research area due to their ability for directive operation and electrical beam-steering, e.g., in wireless communication systems, radars and sensors, and space technology.

2. Antenna for RFID tag (Period 2)

- This topic deals with electrically small antennas, multi-resonant impedance matching, co-design of antennas and IC-circuits, and the effect of the nearby objects on the performance of the antenna.



The course consists of two practical antenna design tasks in Periods 1 and 2



You will learn various skills in this course

What do these working life skills mean to you?

Information
searching and
critical viewpoint
of found
information

Internal entrepreneurship

Project management

Social skills

Complex problem solving

Knowing one's own strengths and
weaknesses for individual development

Critical thinking

Creativity

Group working and
coordinating work with others

Ability to apply theory
on practical problems

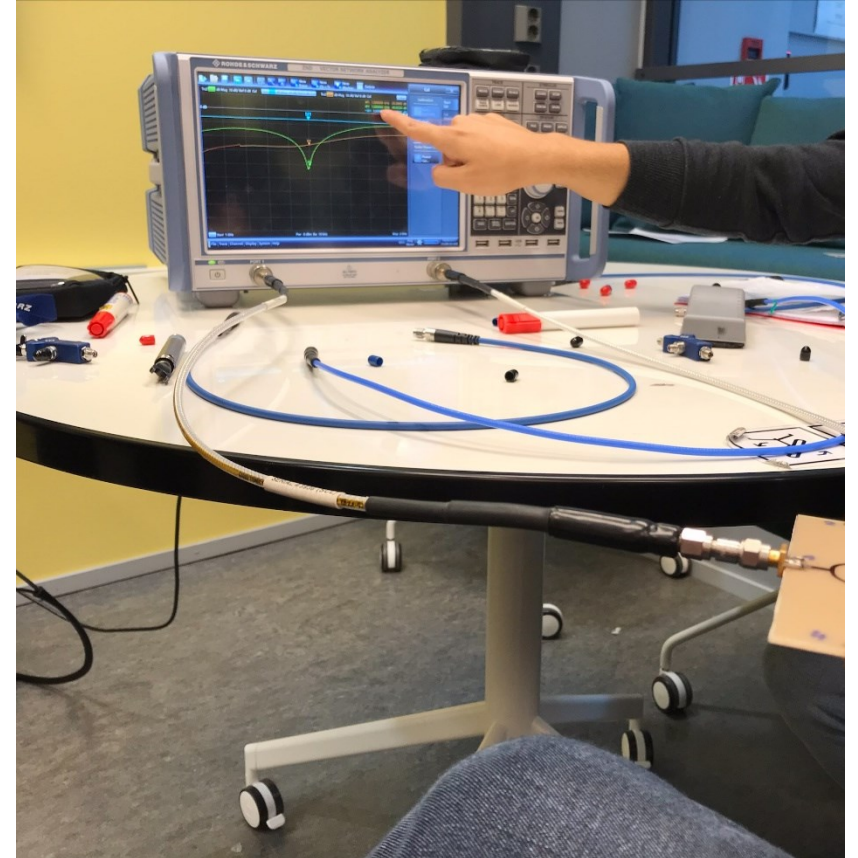
The list defines ten most important **working life skills** according to World Economy Forum and TEK (Union of Academic engineers and architects in Finland).

You will learn various skills in this course

- **Complex problem** (solving) means an assignment or problem which might be defined somewhat unclear, it is not straightforward to solve, and there might be several alternative solutions or even no (good) solutions at all.
- **Critical thinking** means that one can find thorough judgements before making decisions or opinions. Critical thinkers also realize those cases when there is too little facts on giving a reasonable opinion.
- **Creativity** is an ability to find new and somehow valuable ideas or viewpoint.
- **Project** (management) means setting up planned and interrelated tasks over a fixed period for achieving an intended goal.
- **Information searching** means using various independent sources (e.g., books, scientific articles, internet, expert interviews) in parallel for finding the facts among versatile information.
- **Ability to apply theory on practical problems** means that one can use the fundamental theories of physics and (electrical) engineering for explaining (new) phenomena in research, development and innovation tasks.
- **Internal entrepreneurship** refers to “game changer” attitude of a committed, enthusiastic, and self-directed employee (inside an organization) who has an aim for turning ideas into new practices, profitable products, or services.

You will learn various skills in this course

- **After successful completion of the course, the student can work on an antenna project on the competent performer level**
 - i.e., the student's working is well-planned and productive, and one can recognize and propose suitable approaches in real-world situations.
- The main idea of the course is to **educate you for working life, especially on antenna and RF-related tasks, and to improve your learning-to-learn skills.**



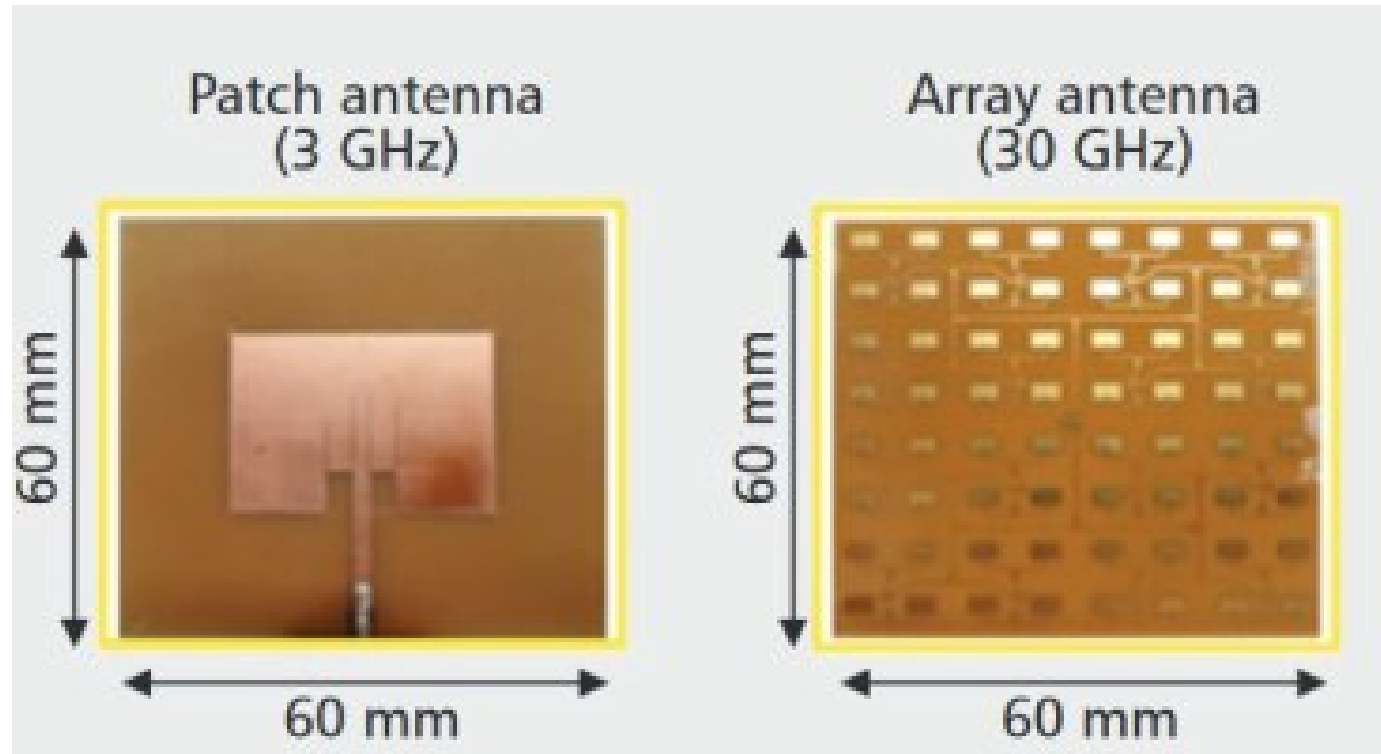
The evaluation aims at giving constructive feedback

- The evaluation objects are – i.e., the grade is affected by
 - Topic 1
 - Topic 2
 - Individual learning and development
 - The grade is not necessary the arithmetic average, but it allows to weight individual learning and development more.
- Individual learning and development are affected by
 - Regularity of working
 - Usage of antenna design and evaluation tools
 - Ability to exploit instruction and show own initiatives
 - Quality of the outputs
 - Presentation of the results and participation in seminar working
 - Achievement of the applicable (i.e., situational flexibility) learning outcomes
- In practice, the evaluation of the individual part comes through individual outputs and activity during the contact sessions

Antennas are essential part of a radio link

- Well known Friis transmission formula:
$$P_r = G_t G_r \left(\frac{\lambda}{4\pi r} \right)^2 P_t$$
- Often interpret $P_r \propto \lambda^2$ - i.e., are “high” frequencies bad choice in terms of the received power or link range?

Antennas are essential part of a radio link



If A_e is constant,
there is no
frequency-
dependent term in
the Friis formula

$$G_r = \frac{4\pi}{\lambda^2} A_e \quad P_r = G_t \frac{4\pi}{\lambda^2} A_e \left(\frac{\lambda}{4\pi r} \right)^2 P_t = G_t A_e \frac{1}{4\pi r^2} P_t$$