**Build a Small Radar System Capable of Sensing Range, Doppler, and Synthetic Aperture Radar Imaging**

* [Resource Home](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm)
* [Syllabus](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/syllabus)
* [Lecture Notes](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/lecture-notes)
* [Projects](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects)
* [Related Resources](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/related-resources)
* [Download Resource Materials](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/download-resource-materials)



A synthetic aperture radar (SAR) image of Alexander Calder’s sculpture La Grande Voile, generated by one of the student laptop-based radar systems. (Radar system photo and overlaid SAR image courtesy of the students, used with permission. Underlying Google Maps satellite image © Google and GeoEye, all rights reserved, excluded from our Creative Commons license; for more information, see <http://ocw.mit.edu/fairuse>.)

**Instructor(s)**

Dr. Gregory L. Charvat

Mr. Jonathan H. Williams

Dr. Alan J. Fenn

Dr. Steve Kogon

Dr. Jeffrey S. Herd

[Cite This Resource](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm)

* [inShare](javascript:void(0);)
* [Resource Description](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm#description)
* [Related  
  Content](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm#related)

**Resource Features**

* [Lecture notes](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/lecture-notes/)
* [Projects and examples](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/)

**Course Description**

Are you interested in building and testing your own imaging radar system? MIT Lincoln Laboratory offers this 3-week course in the design, fabrication, and test of a laptop-based radar sensor capable of measuring Doppler, range, and forming synthetic aperture radar (SAR) images. You do not have to be a radar engineer but it helps if you are interested in any of the following; electronics, amateur radio, physics, or electromagnetics. It is recommended that you have some familiarity with MATLAB®. Teams of three students will receive a radar kit and will attend a total of 5 sessions spanning topics from the fundamentals of radar to SAR imaging. Experiments will be performed each week as the radar kit is implemented. You will bring your radar kit into the field and perform additional experiments such as measuring the speed of passing cars or plotting the range of moving targets. A final SAR imaging contest will test your ability to form a SAR image of a target scene of your choice from around campus; the most detailed and most creative image wins.

**Acknowledgement and Disclaimer**

This work is sponsored by the Department of the Air Force under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, conclusions and recommendations are those of the authors and are not necessarily endorsed by the United States Government.

**Syllabus**

* [Resource Home](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm)
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**Course Meeting Times**

Lectures: 5 sessions over 3 weeks

**Prerequisites**

Participants are expected to supply their own laptop with MATLAB® installed and have some experience with the use of MATLAB.

You do not have to be a radar engineer, but it helps if you are interested in any of the following: electronics, amateur radio, physics, or electromagnetics.

**Course Objectives**

To generate student interested in applied electromagnetics, RF, analog, signal processing, and other (often tedious) engineering topics by building a capable short-range radar sensor and using it in a series of field tests. Students have a vested interest in making their own radar work properly, causing them to dig deeper into these subjects on their own volition thereby providing a self-motivated learning experience.

**Calendar**

| **SES #** | **LECTURES** | **ACTIVITIES** |
| --- | --- | --- |
| 1 | Radar basics | Introduce project |
| 2 | Antenna design | Doppler experiment |
| 3 | Modular system RF design | Ranging experiment |
| 4 | Synthetic Aperture Radar (SAR) imaging | SAR imaging experiment |
| 5 | Presentation of student field experiment results | |

**Lecture Notes**

* [Resource Home](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm)
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This table presents selected lecture slides.  A presentation introducing the radar design project can be found on the [projects](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects) page.

| **SES #** | **TOPICS** | **INSTRUCTORS** | **LECTURE SLIDES** |
| --- | --- | --- | --- |
| 1 | Radar basics | Dr. Steve Kogan | not available |
| 2 | Antenna design | Dr. Alan J. Fenn | ([PDF - 1.6MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/lecture-notes/MITRES_LL_003IAP11_lec02.pdf)) |
| 3 | Modular system RF design | Mr. Jonathan H. Williams | ([PDF - 2.3MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/lecture-notes/MITRES_LL_003IAP11_lec03.pdf)) |
| 4 | Synthetic Aperture Radar (SAR) imaging | Dr. Gregory L. Charvat | ([PDF - 1.8MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/lecture-notes/MITRES_LL_003IAP11_lec04.pdf)) |

**Projects**

* [Resource Home](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/index.htm)
* [Syllabus](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/syllabus)
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Students will work in teams of 3 to build their radar, and conduct a sequence of experiments as the radar kit is implemented. You will bring your radar kit into the field and perform additional experiments such as measuring the speed of passing cars or plotting the range of moving targets. A final SAR imaging contest will test your ability to form a SAR image of a target scene of your choice from around campus; the most detailed and most creative image wins.

**Radar Features**

* Coherent FMCW architecture
* S-band
* Uses coffee cans for transmit and receive antennas
* 6 mini-circuits components
* 1 quad op-amp as video gain stage and anti-alias filter
* Analog ramp generator with trigger output
* Connects to audio input of your computer for digitization of video and triggering
* Records a .wav file of your experiments
* MATLAB® scripts read the .wav files and sort out triggered pulses and groups of pulses to process the 3 modes of operation
* 3 modes of operation include; doppler vs. time, range vs. time, Synthetic Aperture Radar imaging

**Radar Design**

Radar System design slides: block diagram, schematics, bill of material, and fabrication instructions ([PDF - 4.6MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/MITRES_LL_003IAP11_proj_in.pdf))

Block diagram (high resolution image) ([JPEG](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/proj_block.jpg))

Circuit schematics (high resolution image) ([JPEG](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/proj_schematic.jpg))

MATLAB is presumed installed on your laptop. Some MATLAB code is supplied below for each experiment. (The utility dbv.m is a function which takes the 20\*log10(abs(your radar signal)) — used throughout the experiments.)

**Experiments**

| **EXPERIMENTS** | **SUPPORTING FILES** |
| --- | --- |
| Experiment 1: Doppler vs. time ([PDF](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/MITRES_LL_003IAP11_exp01.pdf)) | MATLAB and sample WAV ([ZIP - 5.7MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/doppler_files.zip)) (This ZIP file contains: 2 .m files and 1 .wav file.) |
| Experiment 2: Ranging vs. time ([PDF](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/MITRES_LL_003IAP11_exp02.pdf)) | MATLAB and sample WAV ([ZIP - 12.5MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/ranging_files.zip)) (This ZIP file contains: 2 .m files, 1 .wav file and 1 .tif image.) |
| Experiment 3: SAR imaging ([PDF](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/MITRES_LL_003IAP11_exp03.pdf)) | MATLAB and sample WAV ([ZIP - 44.7MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/sar_files.zip)) (This ZIP file contains: 1 .jpeg image, 3 .m files, 1 .wav file and 2 .mat files.) |

**Selected Final Results**

Presentation of student field experiment final results ([PDF - 4.5MB](http://ocw.mit.edu/resources/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/projects/MITRES_LL_003IAP11_proj_re.pdf))

Selected student team websites

* [Team 1](http://web.mit.edu/kimt/www/radar/) (winner of the class imaging contest)
* [Team 2](http://goretkin.blogspot.com/)