BUILDING A DRONE

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Instructor Summary: *Building A Drone*

This document provides instructor guidelines for one of the ten integrated curriculum projects developed for the NSF-funded Necessary Skills Now (NSN) project (award #1501990). The NSN project partners consist of CORD and three national centers supported through the NSF's Advanced Technological Education (ATE) program: National Center for Systems Security and Information Assurance (CSSIA), Florida Advanced Technological Education Center (FLATE), and South Carolina Advanced Technological Education National Resource Center. The NSN project is designed to integrate employability skills into technical exercises, activities, and labs. The project partners created self-contained instructional modules vertically aligned to associate degree programs in **mechatronics/automation in manufacturing** and **cybersecurity in information technology**. (The activities described in this document support courses in manufacturing.) Six categories of employability skills, repeatedly mentioned in workforce surveys and research reports, served as the focus of the integrated curriculum:

skill category 1 TEAMWORK	*skill category* 2 PROBLEM SOLVING	*skill category* 3 VERBAL COMMUNICATION
skill category 4 WRITTEN COMMUNICATION	*skill category* 5 DEPENDABILITY/WORK ETHIC	*skill category* 6 PLANNING AND ORGANIZING

Project Overview

Purpose

The purpose of the project described in this module is to integrate employability skills (teamwork, problem-solving, verbal communication, written communication, dependability/work ethic, and planning and organizing skills) into activities that focus on designing and building a drone.

Courses for Implementation

- Introduction to Electronics
- Solid Works Fundamentals
- Industrial Safety
- Introduction to Quality
- Materials and Process 1
- Introduction to Machining
- Soldering

Key Terms/Major Topics

- Mechanical assembly (mechatronics)
- CAD
- Safety
- Quality

Discussion

Industry Scenario

Offshore oil rigs are inherently dangerous places to work. Putting people in airborne craft such as helicopters or in waterborne craft such as tenders may lead to injury. Equipment failure can lead to injuries of passengers and/or operators. Weather conditions are constantly changing on the sea, and high winds can create safety issues for either craft.

The Center for Disease Control and Prevention (CDC) records the number of injuries incurred at workplaces. Between 2003 and 2010, the CDC reported over half of fatal accidents on offshore oil rigs were transportation related (http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6216a2.htm).

The American Petroleum Institute (API) lays out the procedures for inspecting, maintaining, repairing, and remanufacturing drilling equipment. API states that the scope and frequency of inspections and maintenance depend on factors such as environmental conditions, equipment age, and estimated dynamic loads. In other words, the rougher the conditions, the more inspections and maintenance required (http://www.api.org/~/media/files/publications/addenda-and-errata/exploration-production/7l_e1_a1.pdf?la=en).

Oil exploration companies with offshore rigs located in the Gulf of Mexico must regularly inspect pilings and decking under rig platforms. Because of ocean wave turbulence, it is not effective to send boats to do the inspections. What less hazardous means could be used?

Drones are able to hover, send live pictures taken from different angles, and fly in tight places. In this scenario, the platform supervisor has asked your team to build a remote-control quadcopter drone with a high-definition camera to inspect pilings and decking in real time. The drone will send a live video signal to the operator or to a control room where inspectors view real-time feed on a large computer screen. Providing real-time data to the operator remotely makes the job much safer.

In this project, you will learn valuable technical skills required to build a drone capable of performing real-time inspections. You will also lean "soft skills" that every employer looks for in a job applicant:

1. Teamwork
2. Problem solving
3. Dependability/work ethic
4. Planning and organizing
5. Written communication
6. Verbal communication

Students will assume the roles of technicians, technologists, and engineers who compose the team(s) in charge of the design and assembly process.

In the manufacturing industry it is common for production teams to keep a record of the manufacturing process of a given product. A manufacturing production logbook is a useful tool for recording the stepwise process used in manufacturing a product. Manufacturing logbooks vary in format from simple spreadsheets to complex digital portfolios that include photographs, videos, and detailed notes. Logbooks provide a way to track progress, costs, problems, and solutions. Each project team has been directed by the rig supervisor to create and maintain a logbook for the drone production process. The rig supervisor wants to be able to replicate the production process on other company rigs.

Student Learning Objectives

Technical

- Students should be able to design a drone and fabricate or procure the parts needed for manufacturing the drone.
- Students should be able to complete a successful drone assembly.
- Students should be able to create safe operating procedure guidelines for the drone.
- Students should be able to synthesize a formal presentation from information recorded in their manufacturing logbooks.

Written Communication

- Students should be able to understand basic shop orders, blueprints, and assembly layouts as well as basic drawing requirements.
- Students should be able to read and create written procedural guidelines.
- Students should be able to create written entries for their manufacturing production logbooks. Students should be able to provide well-written presentation documents.

Verbal Communication

- Students should be able to provide and respond to verbal directions.
- Students should be able to communicate progress within their own teams and to the other teams participating in the project.
- Students should be able to demonstrate effective verbal communication skills in presenting the team project.

Teamwork

- Students should be able to work in a variety of team roles to design and assemble a drone.
- Students should promote the success of their teams.

Dependability and Work Ethics

- Students should demonstrate dependability and work ethic while working as team members.
- Students should punctually attend all labs sessions and complete course requirements on time.

Planning and Organizing

- Students should demonstrate the ability to collaborate with their team members to arrange for and plan the time to design and procure their drone parts.
- Students should demonstrate the ability to collaborate with their team members to arrange for and plan the time to assemble their drones.
- Students should demonstrate the ability to collaborate with their team members to arrange for and plan the time to create operational guidelines and schedule test-flight opportunities.
- Students should be able to organize data for inclusion in their manufacturing production logbooks.

Problem Solving

- Students should be able to troubleshoot drone design, assembly, and operation problems.

Proposed Teaching Strategies

This project is divided into four main activities:

Activity 1: Drone design and parts manufacture and/or procurement.

(Option A): Design and produce specified components with Solid Works software and 3-D printers.

(Option B): Select a standard commercial drone design and procure commercially manufactured parts needed to complete drone assembly.

Activity 2: Drone assembly

Activity 3: Preparation of drone for end-user/consumer. Project teams will create instructions for safe operation.

Activity 4: Professional presentation. Each project team will deliver a formal presentation to the project supervisor. Teams will introduce the main ideas for the project as well as details of Activities 1, 2, and 3.

If time does not allow for completion of all suggested activities, instructors can opt to infuse selected activities into their curriculum.

If the class is large, instructors should consider giving students access to resources to build two or more drones to ensure student engagement.

The PowerPoint presentation 2 Drone Project Overview PPT.pptx provides an overview of the project.

The PowerPoint presentation 3 Manufacturing Production and Logistics - Supply Chain Basics PPT.pptx provides an overview of the manufacturing production and logistics supply chain that the project teams will follow.

Instructors should carefully review the industry scenario and reflect on its importance to the overall project. The scenario should serve as an authentic frame of reference for students to experience "real-world" situations in the manufacturing industry through project activities. Industry scenarios help students become more aware of the skills that manufacturing employees (engineers, technologists, technicians, etc.) should possess. Industry scenarios provide a link between academic activities and situations that students may later experience as employees in manufacturing environments.

Instructors should emphasize the employability skills that students are working on during project activities. At the end of each class session, instructors are encouraged to ask students to reflect on the employability skills they are practicing.

Student/Group Activity Steps

ACTIVITY 1

(Option A): Design and produce specified components with Solid Works software and 3-D printers.

(Option B): Select a standard commercial drone design and procure commercially manufactured parts needed to complete drone assembly.

Option A

Activity Preparation

Instructors should reserve lab facilities as needed and make sure all necessary equipment and materials are available.

Instructors should assign students to teams and explain that these teams will work together for the duration of the project. Students will assume the roles of technicians, technologists, or engineers.

Activity Steps

Each team should research and design a drone similar to commercially available units.

Using SolidWorks Software, project teams should complete the drone design and use 3D printing technology to manufacture the needed parts (rotors, main chassis, arms, etc.).

Examples of standard drone main body parts and additional drone parts can be reviewed in the 4 How to Assemble a Standard Drone.pdf and 5 Example Drone Part List.pdf.

During the research, design, and parts procurement process, each team should maintain a production logbook. Students should take notes, pictures, and/or videos of Activity 1 tasks for inclusion in the logbook. Project teams should provide weekly updates to other teams about their progress as well as problems encountered and how they addressed them.

Option B

Activity Preparation

Instructors should reserve lab facilities as needed and make sure all necessary equipment and materials are available.

Instructors should assign students to teams and explain that these teams will work together for the duration of the project. Students will assume roles of technicians, technologists, or engineers.

Activity Steps

Each team should research and select a standard commercial drone design suitable for the project application.

Each team is responsible for the identification, selection, and procurement of parts. The file 5 Example Drone Part List.pdf will help them in this process.

Instructors may choose to order a ready-made kit, such as the one shown at https://www.amazon.com/LHI-Quadcopter-Copter-Controller-propeller/dp/B010FMGUS8/ref=sr_1_1?ie=UTF8&qid=1481813922&sr=8-1&keywords=drone+kit+250.

Examples of main body parts and additional parts can be reviewed in the files 4 How to Assemble a Standard Drone.pdf and 5 Example Drone Part List.pdf.

After students have determined what parts they will need, they should gather information on availability, price, quality, and shipping. Instructors should consider having the teams send requests to multiple vendors to negotiate the best prices. The teams would evaluate bids and select suppliers based on price, delivery, quality, and service.

During the research, design, and parts procurement process, each team should maintain a formal record of study in a production logbook. Students should take notes, pictures, and/or videos of Activity 1 tasks for inclusion in the logbook. Each team should provide a weekly update to the other teams about its progress as well as problems encountered and how they addressed them.

ACTIVITY 2: Drone Assembly

Activity Preparation

Instructors should reserve lab facilities as needed and make sure all necessary equipment and materials are available.

Instructors should give each student access to the file 4 How to Assemble a Standard Drone.pdf.

After all the parts have been ordered, the assembly process can start. If this activity is taught on several occasions, several kits should be ordered and kept on hand to prevent delays.

Instructors should assign students to teams and explain that these teams will work together for the duration of the project. Students will assume the roles of technicians, technologists, or engineers.

Activity Steps

Depending on the availability of resources and instructional time, instructors may opt to have each team assemble only a part of the drone (e.g., chassis assembly, motor assembly, transmitter, receiver, and flight controller programming) rather than the complete drone.

Drone assembly resources have been provided in the Faculty Resources section of this document:

- 4 How to Assemble a Standard Drone.pdf
- Video resource links

Project teams should identify and gather the tools needed for assembly. Students will use a variety of tools. **Note:** Some parts cannot be assembled until sub-assembly tasks have been completed. For example, some of the motor mounts must be assembled before assembling the main chassis.

Some of the wiring connectors will require soldering, so students should have knowledge of soldering (to include general knowledge of the process as well as flux, tip temperature, and what to look for in soldered components). Some of the headers on the flight controller will also need to be soldered.

Students should understand that the manufacturing method they will use is similar to an “assembly line.” Certain parts must be assembled and soldered before the rest of the drone can be put together. Several sub-assembly tasks will be required in this stage.

Instructors should help students see the connections between activity tasks and situations they would encounter in industry. Assembly tasks typically performed in manufacturing operations include tasks such as nonroutine and nonrepetitive production electronic, mechanical, electromechanical assembly; quality assurance and reliability testing; production scheduling and control; and coordinating, planning, and expediting the flow of materials, parts, and assemblies.

This project requires students to use assembly line methods similar to those used in industry. For example, the chassis team will set up the parts needed to assemble the chassis but cannot finish the assembly until the motor team assembles its motor arms. In this situation, the teams must depend on each other. Work ethic and dependability come into play as the actions of any team member affect overall project completion.

During the assembly process, project teams should maintain a formal record of study in a logbook. Students should take notes, pictures, and/or videos of Activity 2 tasks for inclusion in the logbook. Each team should provide a weekly update to other teams about its progress as well as problems encountered and how they addressed them.

ACTIVITY 3: Preparation of drone for end-user/consumer

Project teams will create instructions for safe operation.

Activity Preparation

Instructors should reserve lab facilities as needed and make sure all necessary equipment and materials are available.

After all the drones have been assembled, the process of creating instruction can start.

Instructors should assign students to teams and explain that these teams will work together for the duration of the project. Students will assume the roles of technicians, technologists, or engineers.

Safety is paramount. Before flying the drone, students should be familiar with safe operating procedures. Test-flying locations should be carefully selected, and all activities should comply with FAA regulations. Instructors should ensure that students are knowledgeable in the operation of the drone controls. Students should practice flying smaller drones before attempting to fly larger drones.

Activity Steps

Drones should be programmed without rotors. (If rotors are left during programming, injury might occur.) During the first attempts to fly the drone, all operators and observers should maintain a safe distance.

Before attempting to fly the drone, students should become familiar with drone flying and safety rules. Violation of FAA rules can result in fines or even incarceration. The links below provide an overview of FAA drone operation rules and limitations:

https://www.faa.gov/news/updates/?newsId=86305

https://www.faa.gov/uas/media/Part_107_Summary.pdf

Project teams will research operation instructions for commercially available drones and create a summary of safe operational procedures for their drone.

Below is a link to a phantom drone operation manual:

https://www.wellbots.com/content/DJI/DJI%20Phantom%202%20-%20User%20Manual%20V1.2.pdf

The U.S. Consumer Product Safety Commission (CPSC) also provides guidance on the development of instructions for consumer products (https://www.cpsc.gov/PageFiles/103077/guide.pdf).

During the process of developing end-user/consumer guidelines, project teams should maintain a formal record of study in a logbook. Students should take notes, pictures, and/or videos of Activity 3 tasks for inclusion in the logbook. Each team should provide a weekly update to the other teams about its progress as well as problems encountered and how they addressed them.

ACTIVITY 4: Professional presentation

Each project team will deliver a formal presentation to the project supervisor. Teams will introduce the main ideas for the project as well as details of Activities 1, 2, and 3.

Activity Preparation

Instructors should reserve lab facilities as needed and make sure all necessary equipment and materials are available.

Instructors should assign students to teams and explain that these teams will work together for the duration of the project. Students will assume roles of technicians, technologists, or engineers.

Activity Steps

Each team will create and present a formal presentation of the final results from Activities 1, 2, and 3.

Expected Results

ACTIVITY 1

- Drone research and design
- Identification of parts needed to build the drone
- Manufacture/procurement of needed parts
- Production logbook

ACTIVITY 2

- Drone assembly
- Production logbook

ACTIVITY 3

- Drone instructions for safe operation
- Production logbook

ACTIVITY 4

- Formal presentation delivered by each project team

Extension Options

Drone Packaging

After project teams have assembled their drones, they can design and manufacture packaging for transport. High-quality packaging is important to ensure the safe movement of an item during shipping or transport.

Each team should research and design a special container to carry its assembled drone. The container should have a foam liner designed to carry the drone, remote control, battery charger, and spare batteries (optional).

Project teams should collaborate on design ideas, types of foam, and container styles. Drone weight and shipping requirements should be evaluated and addressed. Most students are familiar with egg crate foam.

Equipment/Materials

Standard classroom technology equipment (computer, projector, etc.)

Computer with SolidWorks software

Computers with Internet access and presentation software (Microsoft PowerPoint, Apple Keynote, Powtoon, Prezi, etc.)

Soldering equipment:

- Adjustable temperature soldering iron
- Solder pot
- Solder
- Flux
- Desoldering equipment
- Flux cleaner

Hand tools:

- Wire cutters
- Wire strippers
- Screwdrivers

Zip ties

Heat shrink tubing (different colors and sizes)

Velcro straps

Radio transmitter and receiver for each drone assembly

3D printer if the 3D CAD design option of the project is used

Miscellaneous drone parts as needed

Instructor Resources

Background Materials

Handouts and Supplemental Materials

2 Drone Project Overview PPT.pptx

3 Manufacturing Production and Logistics - Supply Chain Basics PPT.pptx

4 How to Assemble a Standard Drone.pdf

5 Example Drone Parts List.pdf

6 Teamwork Rubric.pdf

7 Presentation Rubric.pdf

8 Participation Rubric.pdf

9 Example Logbook Assessment Model.pdf

10 Generic Logbook for Excel.xlsx

Additional Resource PowerPoints

11 Safety Summary Resource PPT.pptx

12 Production Summary Resource PPT.pptx

13 Maintenance Summary Resource PPT.pptx

14 Quality Summary Resource PPT.pptx

Provided by Michael Ennis - HARRIS Corporation

Suggested Videos

https://www.youtube.com/watch?v=iCQkdGhkGOc

https://www.youtube.com/watch?v=PXP5hrRhKWI

https://www.youtube.com/watch?v=Hy7iujd50uQ

https://www.youtube.com/watch?v=hPeEiEPawY0

https://www.youtube.com/watch?v=A40qQPKdxlc

https://oscarliang.com/cf-250-frame-mini-quadcopter-build-blackout

Suggested Websites

https://www.fabtolab.com/

http://massiverc.com/

Logbook Overview and Assessment

http://www.webpages.uidaho.edu/mindworks/Capstone%20Design/Project%20Guides/Logbook_Handout.pdf

http://www.technologystudent.com/designpro/manulogbk1.html

http://www.technologystudent.com/despro_flsh/logbok1.html

Assessment

Students should be assessed according to their completion of the tasks and deliverables. Teams should fill out and complete the corresponding forms and documents as required in the activities.

Instructors should grade and provide feedback on the team activities. Each student will receive an individual grade based on individual performance and collaboration with other team members. Instructors can use the provided student evaluation documents as support for grading.

Assessment rubrics have been provided for the following:

Final presentation: Project documentation from beginning to end is part of the students' communication grade. Students should be graded on verbal as well as written communication. Technical writing is reinforced throughout the project through the development and use of a logbook.

Participation: All students should participate and work as team members. The instructor should follow-up on student participation on a regular basis.

Teamwork: All students should participate and work as team members. The instructor should follow up on student participation on a regular basis.

Additional opportunities for assessment include:

Logbook: Each team should create and maintain a manufacturing logbook throughout the project.

Attendance: Students should attend every class. Team members are counting on each other to assemble and complete their parts. Students' participation should reflect their involvement in the project. This would be part of a dependability/work ethic grade.

Observation: The instructor should observe students during the assembly process, making sure students follow lab safety rules. There should be no tolerance for safety violations. Assembly processes should be done in class under the supervision of the instructor.

Instructors should feel free to create additional assessment tools, such as those listed below:

- Additional rubrics
- Performance task checklists
- Observations
- Quizzes, tests
- Writing prompts
- Laboratory reports