INTRODUCTION:

The primary objective of this Project Readiness Package (PRP) is to describe the proposed project by documenting requirements (customer needs and expectations, specifications, deliverables, anticipated budget, skills and resources needed, and people/ organizations affiliated with the project. This PRP will be utilized by faculty to evaluate project suitability in terms of challenge, depth, scope, skills, budget, and student / faculty resources needed. It will also serve as an important source of information for students during the planning phase to develop a project plan and schedule.

In this document, italicized text provides explanatory information regarding the desired content. If a particular item or aspect of a section is not applicable for a given project, enter N/A (not applicable). For questions, contact Mark Smith at 475-7102, mark.smith@rit.edu.

ADMINISTRATIVE INFORMATION:

- Project Name (tentative): Periodontal MeasurementTest System
- Project Number, if known: P13061
- Preferred Start/End Quarter in Senior Design:
  ☐ Fall/Winter ☐ Fall/Spring ☒ Winter/Spring
- Faculty Champion: *(technical mentor: supports proposal development, anticipated technical mentor during project execution; may also be Sponsor)*

Name	Dept.	Email	Phone

For assistance identifying a Champion: B. Debartolo (ME), G. Slack (EE), J. Kaemmerlen (ISE), R. Melton (CE)

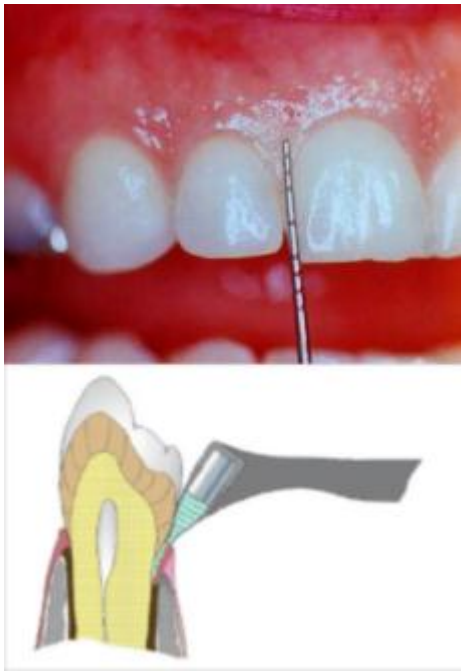
- Other Support, if known: *(faculty or others willing to provide expertise in areas outside the domain of the Faculty Champion)*

Name	Dept.	Email	Phone

- Project "Guide" if known: *(project mentor: guides team through Senior Design process and grades students; may also be Faculty Champion)* Neal Eckhaus
- Primary Customer, if known (name, phone, email): *(actual or representative user of project output; articulates needs/requirements)* Neal Eckhaus
- Sponsor(s): (*provider(s) of financial support)*

Name/Organization	Contact Info.	Type & Amount of Support Committed

PROJECT OVERVIEW:



Background and motivation. Gum disease, or as it is more properly termed "periodontal disease or periodontitis," is the number one chronic infectious disease in the world! It affects over 50% of the American adult population in various stages and is the leading cause of tooth loss. It increases with age, and those people aged 70 years and older have a rate of periodontitis of 86%. The disease usually results from an increased concentration of bacteria in the pocket, or sulcus, between the gums and teeth. These bacteria produce acids and other byproducts, which enlarge the sulcus by eroding the gums and the periodontal ligaments. The sulcus normally has a depth of 1 to 2 millimeters, but in patients with early stages of periodontal disease, it has a depth of 3 to 5 millimeters. By measuring the depth of the sulcus, periodontists can have a good assessment of the disease's progress. Presently, there are no reliable clinical indicators of periodontal disease activity, and the best available diagnostic aid, periodontal probing, can only measure what has already been lost. A method for detecting small increments of periodontal ligament breakdown would permit earlier diagnosis and intervention with less costly and time-consuming therapy, while overcoming the problems associated with conventional probing. Additionally, overwhelming amounts of research has shown that periodontitis is a major cause and contributing factor in heart disease. Some research has even shown periodontitis to be a more important factor in heart disease than smoking! Periodontitis also increases the rate of premature, low birth weight babies, respiratory disease, and it is a great risk factor for those with diabetes. Classical diagnosis of periodontitis does not approach the disease until it is moderate to advance in its negative effects. The painful, low resolution, and non-repeatable, conventional method for probing may be destined for the archives of dental history, thanks to the development of ultrasound probing technologies. The roots of ultrasound probes are in an ultrasound-based time-of-flight technique routinely used to measure material thickness and length in the Nondestructive Evaluation Sciences Laboratory at Langley Research Center. The primary applications of that technology have been for corrosion detection and bolt tension measurements (Spinoff 2005). This ultrasound measurement system was adapted to the Periodontal Structures Mapping System, invented at Langley by John A. Companion, under the supervision of Dr. Joseph S. Heyman.

Problem to be solved. A test fixture is required to enable validation of an innovative ultrasound probe for measuring periodontal disease, that allows the customer to accurately and repeatably measure the depth of a sulcus between a tooth and gum. The fixture will also allow the customer to easily adjust the test by replacing the tooth and altering the aspects of the tooth and gum boundary. The test system will use a standard 10 MHz ultrasound pencil probe and be capable of programmatically controlling the location and orientation of the probe in 5 axis (x, y, z, θ, ϕ)

DETAILED PROJECT DESCRIPTION:

The goal of this section is provide enough detail for faculty to assess whether the proposed project scope and required skills are appropriate for 5th year engineering students working over two quarters. The sequence of the steps listed below may depend on your project, and the process is usually iterative, so feel free to customize. Emphasis is on the "whats" (qualitative and quantitative), not the "hows" (solutions), except for the section on "potential concepts," which is necessary to assess the appropriateness of required skills and project scope. Not all of the information in this section may be shared with students. (Attach extra documentation as needed).

- Customer Needs and Objectives: *Comprehensive list of what the customer/user wants or needs to be able to do in the "voice of the customer," not in terms of how it might be done; desired attributes of the solution.*

Customer Need #		Description
CN1	1	Ability to vary the sulcus depth, with an resolution of 0.1mm.
CN2	1	Ability to measure sulcus depth with an accuracy of +/- 0.1 mm.
CN3	1	Ability to quickly alter the geometry of the tooth in the fixture.
CN4	1	Ability to quickly alter the physical relationship of the tooth with respect to the gum.
CN5	1	Ability to programmatically accurately control the orientation of the ultrasound probe within the test fixture in 5 axis (x, y, and z axis, as well as angles in the xy and yz planes).
CN6	1	Ability to programmatically start and stop data collection from the ultrasound device during the test.
CN7	1	Ability to use ultrasound couplers from standard gel to semisolid couplers.
CN8	1	A tooth that is not made from biomaterials that has similar ultrasound properties as human tooth.
CN9	1	A gum that is not made from biomaterials that has similar ultrasound properties as human gum tissue.
CN10	1	A bone that is not made from biomaterials that has similar ultrasound properties as human bone.
CN11	1	Ability to replace the proxy tooth, gum and bone system with a human or pig mandible.
CN12	1	Ability to replace the pencil probe ultrasound system with an alternate system that can maintain the physical relationship between the ultrasound tip and the dental components.

- Functional Decomposition: *Functions and sub-functions (verb-noun pairs) that are associated with a system/solution that will satisfy customer needs and objectives. Focus on "what" has to be achieved and not on "how" it is to be achieved – decompose the system only as far as the (sub) functions are solution independent. This can be a simple function list or a diagram (functional diagram, FAST (why-how) diagram, function tree).*

See attached Function Tree

- Specifications (or Engineering/Functional Requirements): *Translates "voice of the customer" into "voice of the engineer." Specifications describe what the system should (shall) do in language that has engineering formality. Specifications are quantitative and measureable because they must be testable/verifiable, so they consist of a metric (dimension with units) and a value. We recommend utilizing the aforementioned functional decomposition to identify specifications at the function/sub-function levels. Target values are adequate at this point – final values will likely be set after students develop concepts and make tradeoffs on the basis of chosen concepts. Consider the following types of specifications: geometry (dimensions, space), kinematics (type & direction of motion), forces, material, signals, safety, ergonomics (comfort, human interface issues), quality, production (waste, factory limitations), assembly, transport/packaging, operations (environmental/noise), maintenance, regulatory (UL, IEEE, FDA, FCC, RIT).*

- Constraints: *External factors that, in some way, limit the selection of solution alternatives. They are usually imposed on the design and are not directly related to the functional objectives of the system but apply across the system (eg. cost and schedule constraints). Constraints are often included in the specifications list but they often violate the abstractness property by specifying "how".*

- Project Deliverables: *Expected output, what will be "delivered" – be as specific and thorough as possible.*

- Budget Estimate: *Major cost items anticipated.*
  - 10 MHz ultrasound probe.

- Intellectual Property (IP) considerations: *Describe any IP concerns or limitations associated with the project. Is there patent potential? Will confidentiality of any data or information be required?*

  None.

- Other Information: *Describe potential benefits and liabilities, known project risks, etc.*

- Continuation Project Information, if appropriate: *Include prior project(s) information, and how prior project(s) relate to the proposed project.*

STUDENT STAFFING:

- Skills Checklist: *Complete the "PRP_Checklist" document and include with your submission.*

- Anticipated Staffing Levels by Discipline:

Discipline	How Many?	Anticipated Skills Needed (*concise descriptions*)
EE	2	EE1 and EE2: Analysis of requirements and purchasing of motors. Implementation of motor control, Labview programming and DAQ to supply and measure user defined current or voltage profiles. (Core skills: Motor control, instrumentation and advanced Labview programming and DAQ.)
ME	4	ME1: Analysis and lead physical design of fixture to hold ultrasound probe. CAD drawing. Material choices and parts. Machine work and taking the lead in assembly with other team members. (Core skills: 3D CAD and machining. Mechanical design and materials.) ME2: Analysis and lead physical design of dental fixture to hold bone, tooth and gum proxies. CAD drawing. Material choices and parts. Machine work and taking the lead in assembly with other team members. (Core skills: 3D CAD and machining. Mechanical design and materials.) ME3: Research non-biomaterials for use as gum, tooth and bone proxy within test fixture. Material choices. (Core skills: material properties with respect to wave propagation). ME4: Assist with ME1, ME2 and ME3.
ChemE		
ISE		

Other		

OTHER RESOURCES ANTICIPATED:

Describe resources needed to support successful development, implementation, and utilization of the project. This could include specific faculty expertise, laboratory space and equipment, outside services, customer facilities, etc. Indicate if resources are available, to your knowledge.

Category	Description	Resource Available?
Faculty	**Mechanical engineering professor with experience using ultrasound equipment for nondestructive measurement techniques.**	☐
		☐
		☐
Environment		☐
		☐
		☐
Equipment	**10 MHz A-Scan ultrasound system with PC interface**	☐
		☐
		☐
Materials		☐
		☐
		☐
Other		☐
		☐
		☐

Prepared by: _____ Date: _____