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): Wearable Air Quality Monitor for Particulate Matter
- Project Number, if known: P13625
- 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
Sarah Brownell	Various	sabeie@rit.edu	585-330-6434 cell, no txt

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
Jim Myers	CMS	jamisr@rit.edu	475-4772
Steve Weinstein	Chem eng	sjweme@rit.edu	585-388-0022

- Project "Guide" if known: *(project mentor: guides team through Senior Design process and grades students; may also be Faculty Champion)*

  Sarah Brownell, sabeie@rit.edu, 585-330-6434 cell, no txt

- Primary Customer, if known (name, phone, email): *(actual or representative user of project output; articulates needs/requirements)*
- Sponsor(s): *(provider(s) of financial support)*

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

PROJECT OVERVIEW: *2-3 paragraphs that provide a general description of the project – background, motivation, customers, problem you're trying to solve, project objectives.*

Poor air quality is responsible for as many as 50,000 premature deaths annually in the United States and is linked to illnesses such as asthma, heart attacks and other respiratory and cardiovascular problems costing more than $150 billion per year[1]. In developing countries, respiratory illnesses associated with poor air quality cause 2 billion deaths a year, and are the number one killer of children under 5 years old[2]. Understanding the nature of people's exposure to various pollutants is an important step toward helping to reduce it. However, technologies and systems are not yet able to facilitate large scale, distributed, real time monitoring.

This MSD project was inspired by the "My Air, My Health Challenge" sponsored by the US Environmental Protection Agency and US Department of Health and Human Services (http://www.health2con.com/devchallenge/my-air-my-health-an-epahhs-challenge/). The Challenge is to design a wearable monitor that can measure and transmit air quality parameters and human physiological response (eg. heartrate, breathing, pulse oxigenation, pulse CO oxigenation, etc) in real time so that connections between air quality and health can be better understood and leveraged. The challenge aligns well with the research needs of various RIT faculty members. For example, Dr. James Myers in the Center for Multidisciplinary Studies is interested in studying the health implications faced by the poor who heat with coal stoves in Croatia and cook with charcoal in Haiti. Dr. Rob Stevens in KGCOE is working to improve cook stoves for developing countries using thermo electrics (see MSD Team P12442: https://edge.rit.edu/edge/P12442/public/Home, MSD Teams P12442 are P10461, 11461, and 11462 also worked on this effort). The stoves are designed to burn more efficiently, reducing fuel use and, theoretically, air pollution stemming from incomplete combustion.

Figure 1: Team P12442's stove testing

Much of the research on the connections between air quality and health are based on controlled exposures in lab environments. Many cities monitor air quality to make sure they fall within EPA regulations, provide community warnings when certain substances are elevated, and work to reduce the contamination, but little is known about the connection between what is present in the air and a person's physiological response in real time while going about their everyday activities. Also, the distribution of the contaminants within a city may vary significantly by neighborhood or elevation, leaving some people more exposed than others. Knowing this information would help individuals and communities better protect their health, especially for those with illnesses that can be aggravated by poor air quality.

The goal of this MSD project is to select and integrate existing air quality and physiological sensor technologies into a wearable personal device that will provide beneficial real time information to users, doctors, and policy makers. The team will also work on developing the software interface for collecting, analyzing and displaying the information. The team should begin by researching links between air quality and health, existing sensor technologies, and existing air quality monitors in order to choose the most technically feasible system that will provide the most beneficial health information at the lowest cost.

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.*

No.	Importance	Need: The air quality monitor system…
CN1	9	Tracks one or more pollutant of concern.
CN2	9	Tracks one or more physiological metric.
CN3	9	Records time and geographic location in high resolution.
CN4	3	Is sensitive to small changes in pollutant levels or physiological metrics.
CN5	9	Takes frequent readings.
CN6	9	Provides real time feedback to the user.
CN7	3	Stores and compiles data on user exposure over time to allow medical providers to use data during diagnosis, treatment, and prevention of illnesses.
CN8	9	Allows data from multiple monitors to be compiled, analyzed and visualized.
CN9	9	Uses existing communication networks.
CN10	9	Is easy to use.
CN11	9	Is wearable/portable.
CN12	9	Fits user's individual lifestyle (flexible use).
CN13	9	Is comfortable.
CN14	3	Is stylish.
CN15	9	Resists damage from normal activities (water, dust, impact).
CN16	3	Resists interactions that could affect the data caused by daily activities (movement, temperature, electro-magnetic field, etc.)
CN17	9	Is reasonably priced for wide scale distribution (US)
CN18	9	Operates without user action for at least 4 hours.

- 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).*

Attach to user	Provide interface for easy carrying (portable)
	Provide interface for physiological sampling

Power internal components	
Sample air	
Sample physiological indicator(s)	
Generate frequent and sensitive data	Generate location data
	Generate time data
	Generate air quality data
	Generate physiological data
	Generate data on device functionality
Manage data	Store data
	Manipulate data
	Analyze data
	Compile data from multiple meters
	Check for errors
Transmit data	
Display data	Display real time data to user
	Display complied user data for medical provider
	Display compiled municipality data for public health agency
Encourage voluntary participation	Be comfortable during normal human motion/activities
	Be stylish
	Be easy to use
	Provide relevant real time data to user

- Potential Concepts*: Generate a short list of potential concepts (solutions) to realize the system and associated functions. This may involve benchmarking or reverse engineering of existing solutions. For each concept and its associated function(s), generate a list of key tasks or skills needed to design and realize the function(s), and identify which disciplines (ME, EE, CE, ISE, …) are likely to be involved in the design and realization of the function(s). See the "PRP_Checklist" document for a list of student skills by department.* ***Potential concepts, skills, and tasks should <u>not</u> be shared with students****.*

- 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 <u>metric</u> (dimension with units) and a <u>value</u>. 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).*

Cust. Needs	Spec No	Specification	Direction	Units	Marginal	Ideal	Notes
CN1		Range of pollutant concentration measured	max	ppm?			should include levels known to have heatlh risk….ex. PM2.5 0-100 ug/m3
CN1, CN4		Sensitivity of pollutant measurement	min	ppm?			
CN2		Range of physiological response measured	max				heart rate or blood oxygen for example
CN2, CN4		Sensitivity of physiological response measured	min				
		Precision of data (not sure if possible to measure?)					
CN3		Accuracy of location (latitude/longitude)	min	+/- m	30	<15	
CN3		Accuracy of elevation	min	+/- m	70	30	
CN3		Records time stamp				yes	is there an accuracy concern here?
CN5		Frequency of data measurments	min	cycles per minute	<=0.1	<=1	
CN6		Provides real time feedback to the user while wearing			no	yes	
CN7		Stores long term exposure data		# of data points?			
CN7		Displays long term exposure data visually				yes	24 hour and yearly averages, running graph?
CN8		Data from multiple sensors can be compiled				yes	each sensor signal needs to be identified so a particular user's data can be compiled by doctor
CN8		Data from multiple sensors can be displayed visually				yes	exposure across geographic can show neighborhoods most affected.
CN8		% of surveyed participants who can correctly answer a question about the visual data without	max	%	50	80	

		added explanation?					
CN9		Uses existing networks for communication				yes	
CN10		% of surveyed participants who can correctly put on and use the sensor without added explanation?				yes	
CN11		Weight	min	kg	5		may depend on how it is carried/worn
CN11, CN12, CN13		% of surveyed particpants reporting the monitor as 5 or more for comfort during everyday activities on a scale of 1-10			70	90	
CN14		% of surveyed particpants reporting the monitor as 5 or more for style on a scale of 1-10			50	70	
CN15		Resistes impacts/crashes	max	IEC60529* Level 1-9	>5	>7	
CN15		Resists dust	max	IEC60529* digit 1 Level 0-6	>4	6	
CN15		Resists water	max	IEC60529* digit 2 Level 0-8	>4	>7	
CN16		depends on the specific sensors chosen…					
CN17		Estimated Cost in lots of 100	min		<500	<200	
CN18		Time before recharge (battery)	hours		>16	>24	

- 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.*

    - Possible, but not required: Proposal to the My Air, My Health Challenge, Oct. 4.
    - Working Prototype
        - Able to test at least one air quality and one physiological parameter
        - Programming structure for managing and displaying data for one or more meters remotely.
    - Bill of Materials

  - Design Drawings for manufacturing or modifying all parts
  - Assembly Plan
  - Test Plan
  - Clearly documented Test Results
  - Technical Paper
  - Poster

- Budget Estimate: *Major cost items anticipated.*

  $500 -- larger budgets must be justified and approved by the end of MSDI.

- 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?*

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

Faculty and students at the University of California at Berkeley have been working on a tool called the UCB Particle Monitor, which can be used as a benchmark for this project. (See: http://ehs.sph.berkeley.edu/hem/?page_id=12) The UCB Particle Monitor measures Particulate Matter concentrations. In 2005 the World Health Organization developed *Air quality guidelines* (AQGs) for various pollutants based on a review of scientific evidence. Particulate Matter (PM) affects more people than any other pollutant. PM exposure is divided into two categories, $PM_{2.5}$ and PM_{10} based on the largest diameter aerodynamic diameter of the particles in microns. $PM_{2.5}$ is more dangerous than PM_{10} since it can penetrate more deeply into the lungs[2].

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

  NA

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	Sensor selection, control for sensors, gps, time, PCB design, sending info remotely, data analysis and display output, possible interface with existing cell phones?
ME	2	sensor selection, casing, portability, attaching to user, help EE/CE with data analysis
CE	1	(More if available) User interface on the device, possibly with a cell phone, and also web based interface for compiling, analyzing and displaying data long term for one sensor as well as compiling data from many sensors
ISE	1-2	Human factors, portability, physiological monitoring
Other	1-2	Chem eng (but I know that they aren't available this time…)

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	James Myers, help understanding user needs	☐
	Steve Weinstein, particle considerations	☐
		☐
Environment	MSD	☐
		☐
		☐
Equipment		☐
		☐
		☐
Materials		☐
		☐
		☐
Other		☐
		☐
		☐

1 National Oceanic and Atmospheric Administration, US Department of Commerce. Accessed 8/27/12 on line at: http://www.noaawatch.gov/themes/air_quality.php

2 World Health Organization Fact Sheet No 313: Air Quality and Health http://www.who.int/mediacentre/factsheets/fs313/en/

Prepared by: Sarah A. Brownell Date: 8/31/12