Northwest Advanced Renewables Alliance

3RD Cumulative Report

April 2014 - March 2015

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A New Vista for Green Fuels, Chemicals, and Environmentally Preferred Products

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NARA

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NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

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Notice

The authors, their respective employers, corporate partners, affiliated universities, and government institutions prepared this annual report. The information within was obtained in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the United States Department of Agriculture National Institute of Food and Agriculture.

NARA Organizational Structure

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ORGANIZATIONAL STRUCTURE

NARA Executive Committee

The Executive Committee is responsible for leading the NARA project and communicating directly with the USDA-NIFA leadership and the Advisory Board. Specific areas of leadership include: working closely with the Project Area Team Leaders to approve the annual work plans and budgets; reviewing and administering subcontracts; approving scope of work for each affiliated individual institution; and supervising staff members.

NARA Executive Committee Members

Ralph P. Cavalieri
Executive Director and Project Director

509-335-5581
cavalieri@wsu.edu

Dr. Cavalieri is currently Associate Vice President for Alternative Energy and Professor of Biological Systems Engineering at Washington State University. He is a Registered Professional Engineer, State of Washington. He served two terms on the Department of Energy's Biomass Research and Development Technical Advisory Committee, and currently serves as the Director of the FAA Center of Excellence for Alternative Jet Fuels and Environment (ASCENT) and as the Associate Director of the Western Sun Grant Center. His research emphasis is on chemical and biochemical process kinetics and sensors.

Michael Wolcott
Project Co-Director

509-335-6392
wolcott@wsu.edu

Dr. Wolcott is a Regents Professor in Washington State University's Department of Civil and Environmental Engineering, a member of the interdisciplinary Materials Science and Engineering faculty, and director of WSU's Institute for Sustainable Design. He is an international leader in the field of natural fiber materials and biopolymers while he has led the development of advanced materials to improve durability, reduce manufacturing costs and pollution, and improve structural performance. He has previously managed nearly $20 million in funding and large research teams for numerous federal agencies, including the Office of Naval Research, the Department of Energy, the USDA, the US Forest Service, and the Federal Highway Administration.

Linda Beltz
Project Development Analyst

253-924-6638
linda.beltz@nararenewables.org

Dr. Beltz is the President and Co-Founder of Steadfast Management Inc. Founded in April 2012, Steadfast Management Inc. provides management and consulting services and is providing Phase and Gate leadership to NARA.

Outside of NARA, Linda is currently VP, Commercial Aerospace Licensing for the Boeing Intellectual Property Licensing Company. Prior to that, Linda was Director, Technology Partnerships at Weyerhaeuser for 12 years, leaving in September 2013. In this role, Linda worked with John Tao to implement Open Innovation at Weyerhaeuser. Linda was responsible for alliances and partner activities with for-profit, non-profit, university and national laboratories, and focused on emerging technology areas such as bio-fuels, bio-products and bio-power. She was also responsible for government contracts.

NARA Advisory Board

The NARA Advisory Board is composed of leaders within a variety of fields such as forestry, chemistry, and engineering. The board's role is to provide an independent overview of NARA's progress towards completing the goals articulated in the USDA NIFA competitive grant no. 2011-68005-30416. The Advisory Board meets annually with NARA and USDA-NIFA leadership, reviews NARA quarterly and annual progress reports, and provides written recommendations to NARA and to the USDA-NIFA. The board is currently composed of six members.

NARA Advisory Board Members

Terrance Cooper
Argo Group International

Dr. Terence Cooper is CEO of Argo Group International, which provides specialized consulting services in chemical and polymer science, materials technology and market and applications development in North America, Europe and Japan. Present areas of major involvement include new product, process and market development in acrylic, methacrylic, olefinic, vinylic and styrenic copolymer systems, strategic research, development and technology portfolio analysis and environmental consulting.

Katrina Cornish
Ohio State University

Dr. Katrina Cornish is the leading U.S. scientific expert, and is internationally recognized as a principal authority, on alternative natural rubber production, properties and products, and on natural rubber biosynthesis in general. As Ohio Research Scholar and Endowed Chair in Bioemergent Materials, Katrina leads a program at The Ohio State University focusing on domestic rubber production, bio-based fillers and fibers, and exploitation of opportunity feedstocks from agriculture and food processing wastes for value-added products and biofuels.

Thomas P Klin
CH2MHill

Thomas Klin serves as Principal Technologist and Director of Aviation Environmental Services for CH2M Hill. In this capacity he oversees the execution of all environmental impact statements (EIS), environmental audits, permitting, environmental compliance and related environmental projects that enable airport development and operation. Thomas specializes in the National Environmental Policy Act (NEPA) process, environmental impact assessment and creative mitigation planning for unavoidable impacts. He also specializes in education of and consensus building between agencies involved in the airport and aviation environmental regulatory process.

Michael Lakeman
Boeing

Dr. Michael Lakeman is currently the Regional Director of Biofuel Strategy for Boeing Commercial Airplanes. His focus is to build the capabilities needed to expand the scale of next-generation biofuels. He joined Boeing after holding the position of Senior Research Scientist at Imperium Renewables in Seattle. Michael serves on the Algae Foundation Board for 2013/2014 and as co-chair of the CAAFI Research and Development Team.

Jack N. Saddler
University of British Columbia

Dr. John (Jack) Saddler is the endowed Professor of Forest Products Biotechnology /Bioenergy and also the former Dean, Faculty of Forestry, at the University of British Columbia. He is a Fellow of the Royal Society of Canada, Canada's highest recognition for scientists, and he has received many other awards such as the International Union of Forest Research Organizations (IUFRO's) Scientific Achievement Award, and the Charles D. Scott award for contributions to the field of "Biotechnology for fuels and Chemicals". Recently, Dr. Saddler received the prestigious 2009 Leadership award, presented from Life Sciences British Columbia for demonstrated leadership in the industry and given to individuals who have assisted in the creation and advancement of the broader life sciences communities over time.

Chuck Hersey
Washington State Department of Natural Resources

Chuck Hersey has worked for the Washington State Department of Natural Resources as a forest health planner since 2012. Chuck's work in the Forest Health Program focuses on forest restoration in eastern Washington including coordination of the forest health hazard warning process, forest landowner outreach, education and technical assistance and biomass utilization. Chuck also serves as the agency's wood energy policy lead and coordinates the Washington State Forest Biomass Coordination Group.

Member and Affiliate Organizations

NARA members and affiliates are the institutions (universities, businesses, governmental entities, and nonprofits) that are signing parties to the NARA Non-disclosure Agreement and are expected to contribute resources, personnel, time, information and other assets to NARA in support the NARA Mission. Member institutions are also signatories to the NARA Intellectual Property Agreement.

Catchlight Energy

Catchlight Energy's vision is to become a major integrated producer of biofuels derived from non-food sources and to deliver renewable transportation products produced from biomass in a manner that is scalable and sustainable—both environmentally and economically. For NARA, they participate with the Pretreatment Team.

Compañía Logística de Hidrocarburos CLH S.A.

CLH is Spain's leader for oil product transportation and storage. CLH Aviation has operated for over 85 years and is dedicated to hydrocarbon storage and logistics in Spain. CLH Aviation will provide a cross-national comparison of fuel logistics, policy, and corporate social responsibility (CSR) issues.

Cosmo Specialty Fibers, Inc.

Cosmo Specialty Fibers, Inc. (CSF) is an affiliate of The Gores Group and was created to restore, restart and operate Weyerhaeuser's former specialty cellulose mill in Cosmopolis, Washington. This facility currently produces a high-quality dissolving wood pulp. As a NARA member organization, CSF will explore available markets for the simple sugars that could be derived from their residual streams.

Facing the Future

Facing the Future is a national education nonprofit that develops and delivers K-12 sustainability curriculum resources that prepare K-12 students in all 50 U.S. states to become engaged, informed global citizens. As a member of NARA, Facing the Future will support the K-12 education efforts for the NARA project.

Gevo, Inc.

Gevo is a leading renewable chemicals and advanced biofuels company. Through the NARA project, Gevo will optimize their conversion technology to convert woody biomass hydrolysate into feedstocks for isobutanol, biojet fuel and other renewable chemicals.

Montana State University

Montana State University Extension Forestry will assist with the NARA Extension Working Group by providing information about the NARA program and research updates to Montana stakeholders.

Oregon State University

Oregon State University is the state's land-grant and leading public research university. A number of NARA researchers work here and contribute primarily to the project's feedstock development and sustainability work.

Pennsylvania State University

Penn State is Pennsylvania's land-grant university. Research dedicated to the NARA project investigates the social sustainability of a wood-based biofuel industry.

Salish Kootenai College

Salish Kootenai College, a tribal university, provides research opportunities tied to biofuels and bio-products from woody biomass.

Steadfast Management

Steadfast Management provides management and consulting services and contributes Phase and Gate and pretreatment/conversion leadership to NARA.

Thomas Spink Inc.

Thomas Spink Inc. is a consulting firm specializing in biomass chemical engineering and assists NARA in co-product development and economic analyses.

University of Idaho

Faculty in the College of Natural Resources and College of Art and Architecture participate in NARA's education and outreach tasks.

University of Minnesota

Efforts from the University of Minnesota's Department of Bioproducts and Biosystems Engineering contribute to the NARA project by developing lignin-based co-products and contributing to the sustainability analyses.

University of Montana

University of Montana contributes to the NARA project by identifying and collecting primary data necessary to assess the woody biomass inventory with particular emphasis on mill and logging residue.

University of Utah

Research at the University of Utah will measure the impacts of forest residuals removal on the forest ecology. Specifically, efforts from this NARA affiliate will measure runoff, nutrient export and sediment erosion from test plots with varying levels of harvest treatments. The effects on microbial communities will also be measured.

University of Washington

Researchers at the University of Washington lead NARA's efforts to develop a complete life cycle assessment of the wood residue to biojet and co-product process. Additionally, members from this university serve as NARA liaison with regional tribal organizations to promote educational opportunities and forestry management analyses.

University of Wisconsin Extension

The University of Wisconsin Extension will contribute to NARA's goal of enhancing bioenergy literacy for students, educators and the general public.

US Forest Service-USDA, Forest Products Laboratory

The Forest Products Laboratory conducts innovative wood and fiber utilization research that contributes to the conservation and productivity of forest resources and sustainably to meet the needs of people for forest products. They contribute pretreatment conversion technology research to the NARA project.

US Forest Service, Pacific Northwest Research Station

The Pacific Northwest (PNW) Research Station is one of seven research centers that are part of the USDA Forest Service. They develop and deliver knowledge and innovative technology to improve the health and use of the Nation's forests and rangelands. They contribute to NARA's outreach tasks.

Washington State University

Washington State University is Washington's original land-grant university and the lead institution for NARA providing leadership, research and administrative services.

Western Washington University

Faculty in Western Washington University's Huxley College of the Environment, along with university's Institute for Energy Studies (IES), are involved in the education and outreach goals of the NARA project.

Weyerhaeuser

Weyerhaeuser creates sustainable solutions to the world's challenges through the development of innovative forest products that are essential to everyday lives. Weyerhaeuser NR Company continues to provide research expertise and leadership to important aspects of the NARA project, specifically with emphasis on feedstock sustainability and sourcing. Through year 3, Weyerhaeuser provided techno-economic analyses and co-product development.

NARA MANAGEMENT

NARA is an integrated project. An overarching challenge facing NARA is to provide a management framework that assists team cooperation, direction and achievement (see Figure OS-1). NARA has implemented multiple strategies to provide administrative services and management tools to the project.

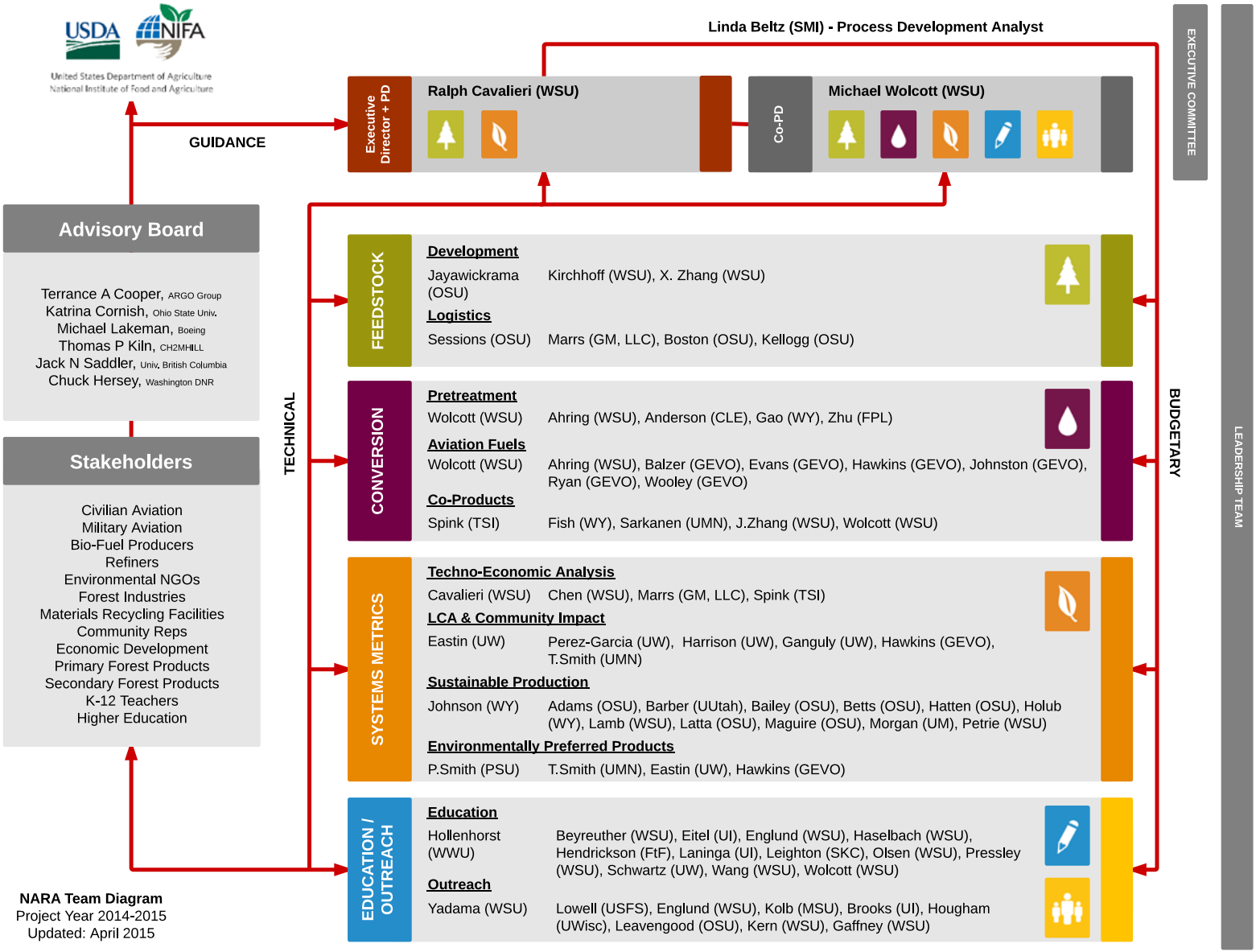

Figure OS-1. The NARA team diagram as of April 2015

NARA PHASE-GATE MODEL

Description of Phase and Gate

The Phase and Gate process is a well-known project management and decision support tool that improves project execution and promotes fact-based decision -making. Phase and Gate processes typically include "Phases", where the project work is completed and "Gates" where decisions for continuation and next Phase objectives are set. Each Phase allows progression from the idea phase to implementation, where Gates ensure that the decisions to continue are based on comprehensive information. NARA developed a customized Phase and Gate process that advances the project through the steps necessary to achieve commercial readiness of a forest residuals to aviation fuels pathway: (1) Feasibility Analysis, (2) Feasibility Validation, (3) Scale Up Readiness and (4) Commercial Options. The process is designed to be adaptable for the range of academic to commercial as well as technical to social work encompassed within the NARA project. Each phase covers key areas of: Technical, Market, Business Models / Integration, Manufacturing, Financial, Health/Safety and Intellectual Assets. Figure OS-2 shows NARA project flow diagram with desired outcomes by project area.

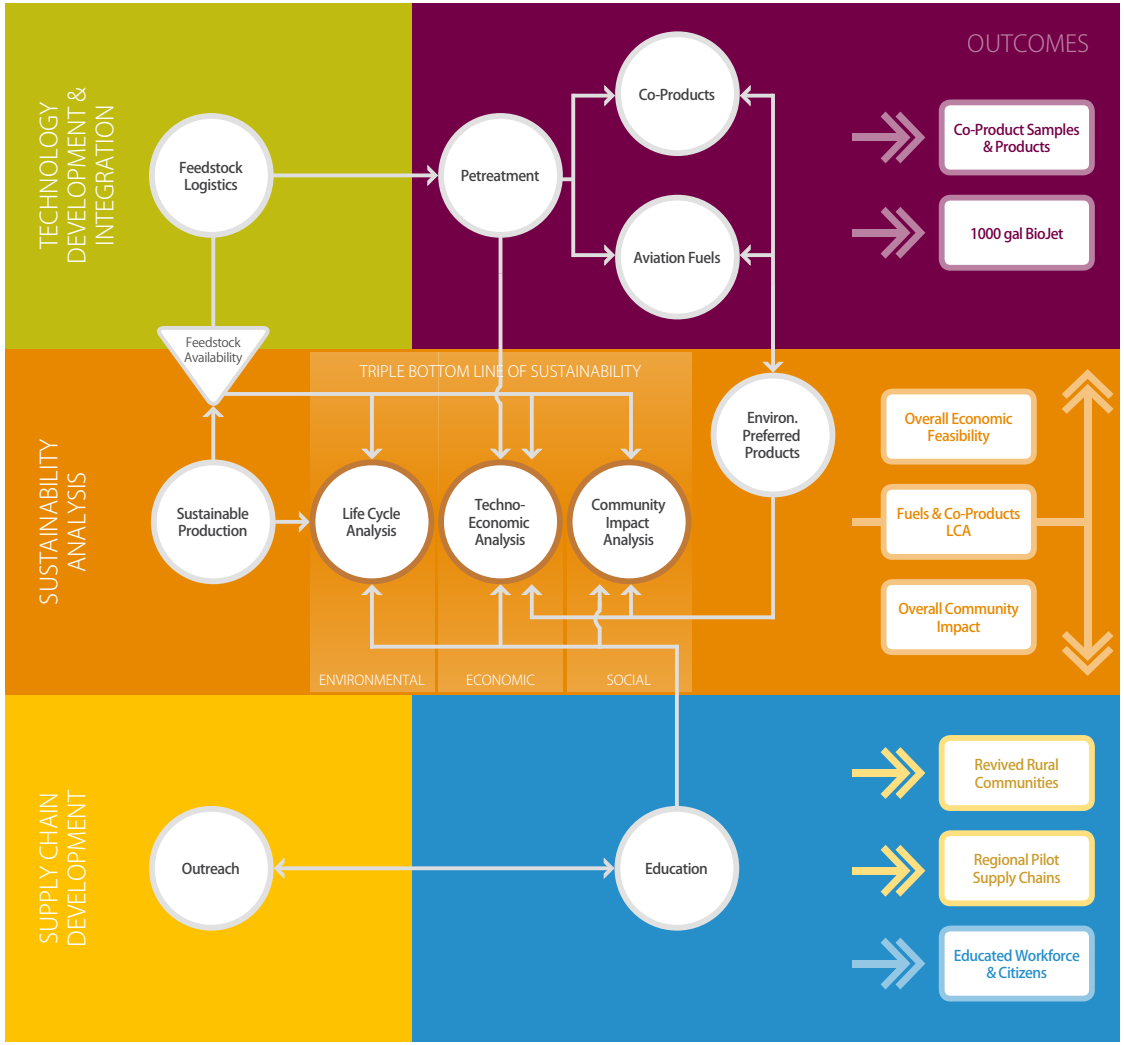

Figure OS-2. NARA project flow diagram with desired outcomes by project area

Activities and Results

Two major Phase and Gate activities were developed during the reporting period of December 2014-March 2015: (1) Initiation of anew Critical Path Milestone map for the overall NARA project and (2) Development of Gate 3 Scale Up Readiness Packet for 1000 Gal Jet and facilitation of the 1000 Gal Jet Gate Review. Alignment of the 1000 Gal Jet project tasks to the 1000 Gal Jet Critical Path Milestones (CPM) previously mapped (3) is in progress.

For activity (1), the 1000 Gal Jet CPM chart (shown in Figures OS-1 and OS-4) was revised based on input from the NARA team during participation in the 1000 Gal Jet planning meeting. The revised CPM chart served as a basis for the task planning for production of 1000 Gal Jet. A key result was NARA's understanding of the timing for biomass pretreatment and production of isobutanol (IBA) and iso-paraffinic kerosene (IPK) in order to meet the goal of flying a jet using the 1000 Gal Jet by the end of NARA Year 5. The timing for these activities is earlier than expected, with a plan to complete the production of jet fuel by the end of 2015. This allows time for other related project tasks to be completed by the end of NARA Year 5.

For activity (2), a template was created and sent to NARA Team Leaders to collect each team's CPM's. There have been delays in getting input from the teams, but 90% have been collected. The CPM's have been reviewed. The CPM's from each team have started to be condensed into the overall CPM's for the NARA project, which will allow the NARA project to determine dependencies in task activities needed for completion of all NARA outputs.

For activity (3), a gate packet template was created for the Gate 3 Scale Up Readiness, 1000 Gal Jet Gate Review. The Gate Packet was used in the March 17, 2015 Gate Review to decide on the facilities and budget for production of 1000 Gal Jet. This activity also included facilitation of the Gate 3 Review. The proposed budget was higher than acceptable to the Gate Keeper. The Gate recommendation was not accepted and a recycle on the budget elements of the recommended path was requested. Once revised budget recommendations are ready for review, another Gate 3 Review will be completed with focus on the budget element.

NARA Year 4 Critical Path Milestones - Production of 1000 Gal Jet

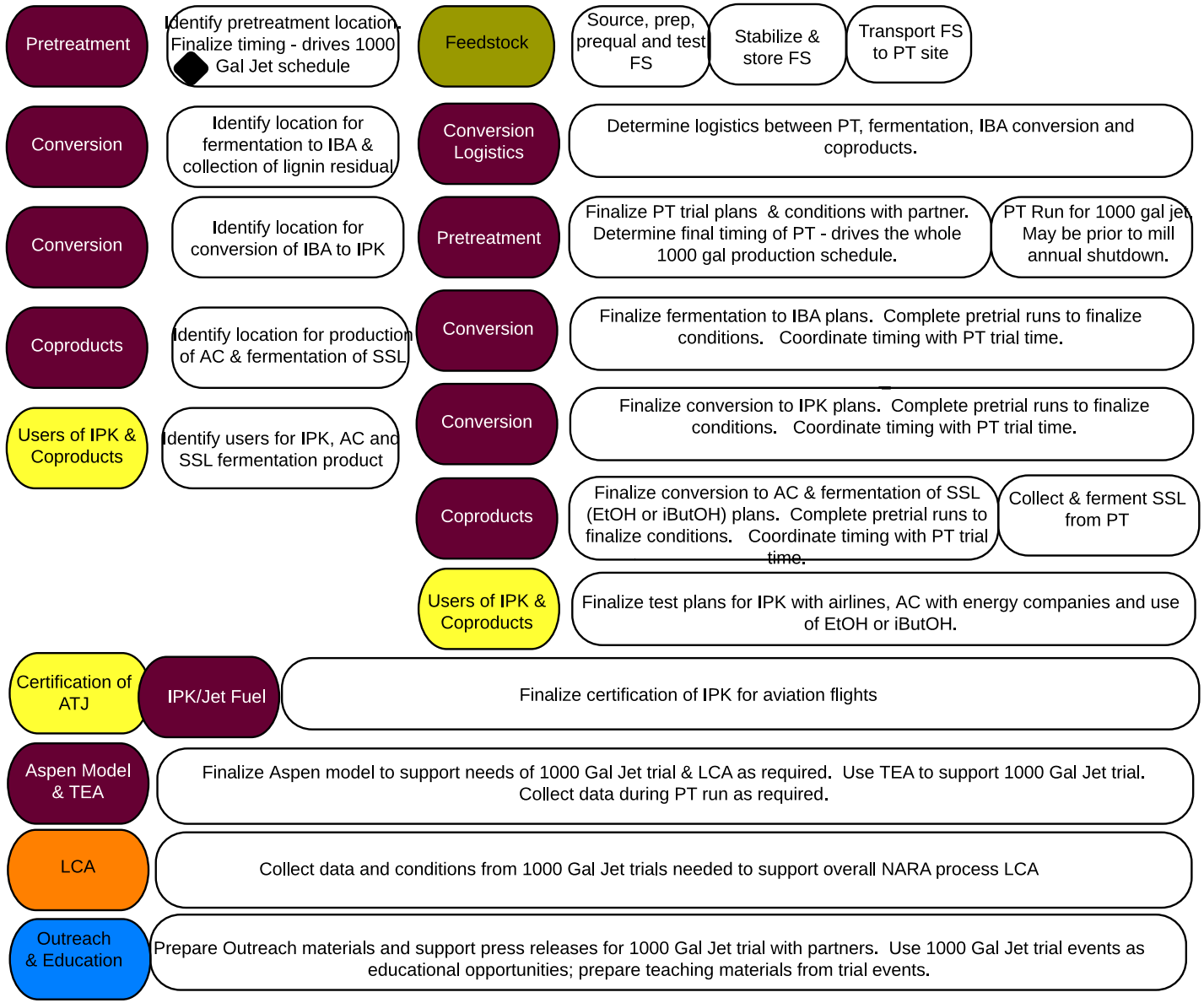

Figure OS-3. NARA Year 4 CPM's for 1000 Gal Jet

NARA Year 5 Critical Path Milestones - Production of 1000 Gal Jet

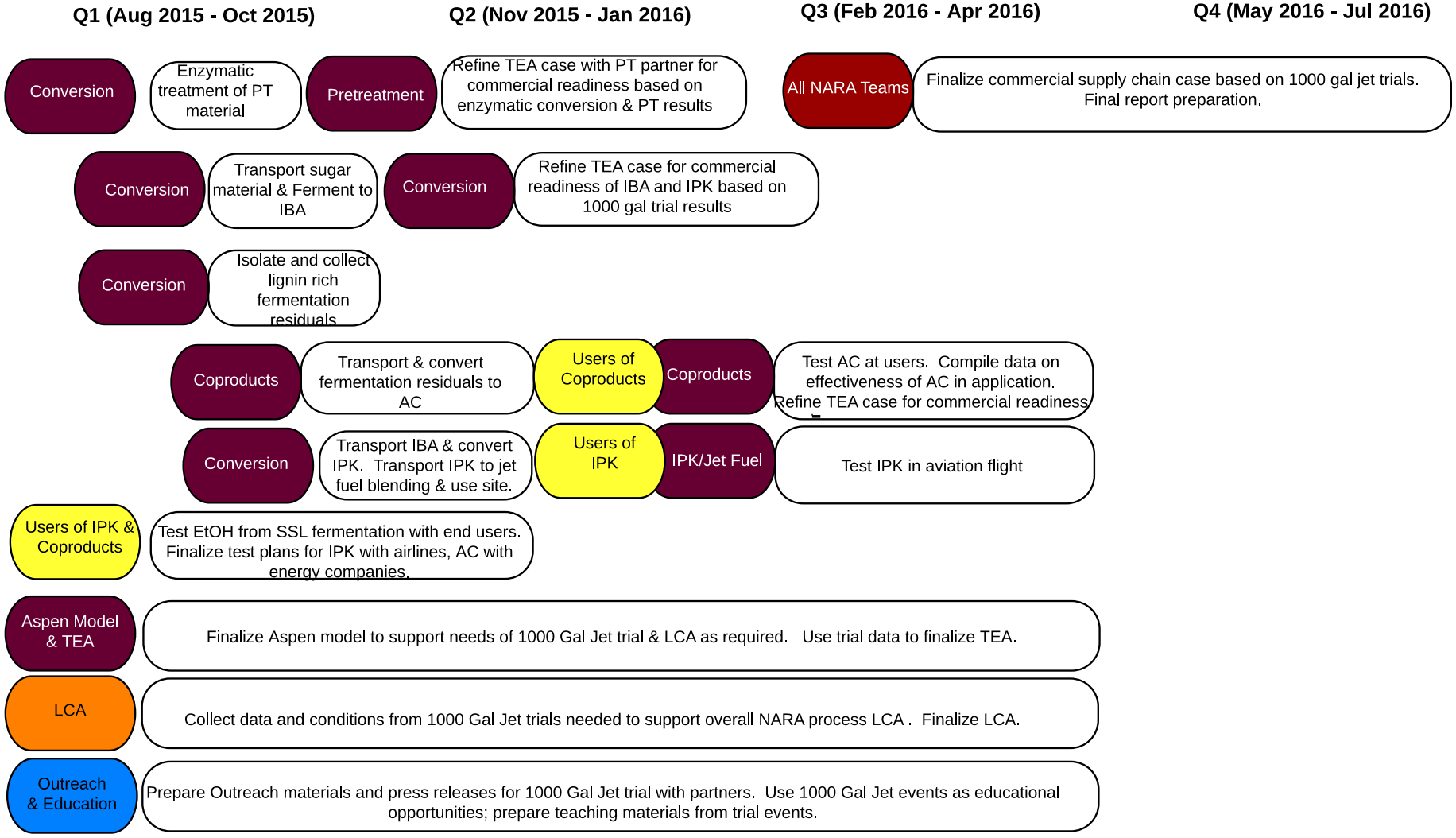

Figure OS-4. NARA Year 5 CPM's for 1000 Gal Jet

Intellectual Property (IP) Management Plan and Non-disclosure Agreement (NDA)

All NARA members endorse a common Intellectual Property (IP) Management Plan and Non-Disclosure Agreement. The purpose of the IP Management Plan is to ensure that the protection process for all IP developed under NARA is well defined and agreed upon in advance of IP creation. By agreeing to the terms in advance, the companies involved are more secure of the commercial prospects for licensing/using the technology, and the rights and responsibilities of the parties protecting IP are clearly defined.

The purpose of the NDA is to allow companies to talk freely and exchange ideas with the government labs and university researchers without worry that their proprietary information will be disclosed or rendered not patentable.

NARA Staff

NARA retains five staff members to assist in administrative and creative needs. All are funded by Washington State University.

Charles Burke
Communications and Publicity Director ccburke@nararenewables.org

Janet Duncan
Project Coordinator duncanj@nararenewables.org

Norman Ong
Intellectual Property Management norman.ong@wsu.edu

Julie Semler
Project Coordinator jsemler@nararenewables.org

Jacob Smith
Graphic Designer/Web Coordinator jsmith@nararenewables.org

COMMUNICATIONS

NARA communicates progress to NARA members, Advisory Board, and the USDA-NIFA leadership. In addition, research and event information is provided to regional stakeholders and to the general public. To accomplish this, NARA hosts meetings, maintains communication tools and includes the communication services of outside partners.

NARA Annual Meeting

NARA holds an annual meeting each year in the fall. Our 2014 annual meeting was held at the Museum of Flight in Seattle. These meetings provide an opportunity for NARA researchers to present their work to the advisory board, the USDA-NIFA leadership, partners, stakeholders and the general public.

NARA Team Leadership Meetings

NARA is composed of eleven working teams grouped with the feedstock, conversion, systems metrics, education and outreach components of the project. Each month, team leaders and the executive committee meet via conference call to ensure that the process is focused on reaching solutions that achieve NARA goals.

NARA Website

The NARA website functions as the central repository for NARA information to the general public; hosts portals like "woodtobiofuels.org" used as a data retrieval tool for educators, professionals and the general public; and contains an intranet feature used to share project information internally among NARA researchers. As of March 31, 2015, the website experienced 59,255 visits with 195,512 page views. The NARA website is at http://nararenewables.org.

NARA Newsletters

NARA distributes a monthly newsletter and a blog written to communicate NARA's progress to the general public and to the NARA team. Past newsletters can be viewed at http://nararenewables.org/news/newsletter.

Forest Business Network

The focus of the Forest Business Network is to help forest product businesses grow and prosper. They work strategically with the NARA Outreach team to develop stakeholder groups and disseminate information within the forestry industry. Their website is https://www.forestbusinessnetwork.com

Ruckelshaus Center

The Center is a joint effort of Washington's two research universities and was developed in response to requests from community leaders. Building on the unique strengths of the two institutions, the Center is dedicated to assisting public, private, tribal, non-profit and other community leaders in their efforts to build consensus and resolve conflicts around difficult public policy issues. For NARA, the center assists the Outreach Team communicate with policy makers. They also help facilitate NARA's internal communications. Their website is http://ruckelshauscenter.wsu.edu/