R+D Team

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COMMERCIAL AVIATION
ALTERNATIVE FUELS INITIATIVE

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R+D Team mission statement

To identify, prioritize and communicate critical technology gaps that, if addressed, would potentially lead to cheaper, scalable, and more widely available production of aviation alternative fuels

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Fuel Readiness Level

FRL	Description	Toll Gate	Fuel Quantity+
1	Basic Principles Observed and Reported	Feedstock /process *principles* identified.	
2	Technology Concept Formulated	Feedstock /*complete* process identified.	
3	Proof of Concept	Lab scale fuel sample produced from realistic production feedstock. Energy balance analysis executed for initial environmental assessment. Basic fuel properties validated.	0.13 US gallons (500 ml)
4.1 4.2	Preliminary Technical Evaluation	System performance and integration studies entry criteria/specification properties evaluated (MSDS/D1655/MIL 83133)	10 US gallons (37.8 litres)
5	Process Validation	Sequential scaling from laboratory to pilot plant	80 US gallons (302.8 litres) to 225,000 US gallons (851,718 litres)
6	Full-Scale Technical Evaluation	Fitness, fuel properties, rig testing, and engine testing *	80 US gallons (302.8 litres) to 225,000 US gallons (851,718 litres)
7	Fuel Approval	Fuel class/type listed in international fuel standards**	
8	Commercialization Validated	Business model validated for production airline/military purchase agreements – Facility specific GHG assessment conducted to internationally accepted independent methodology	
9	Production Capability Established	Full scale plant operational++	

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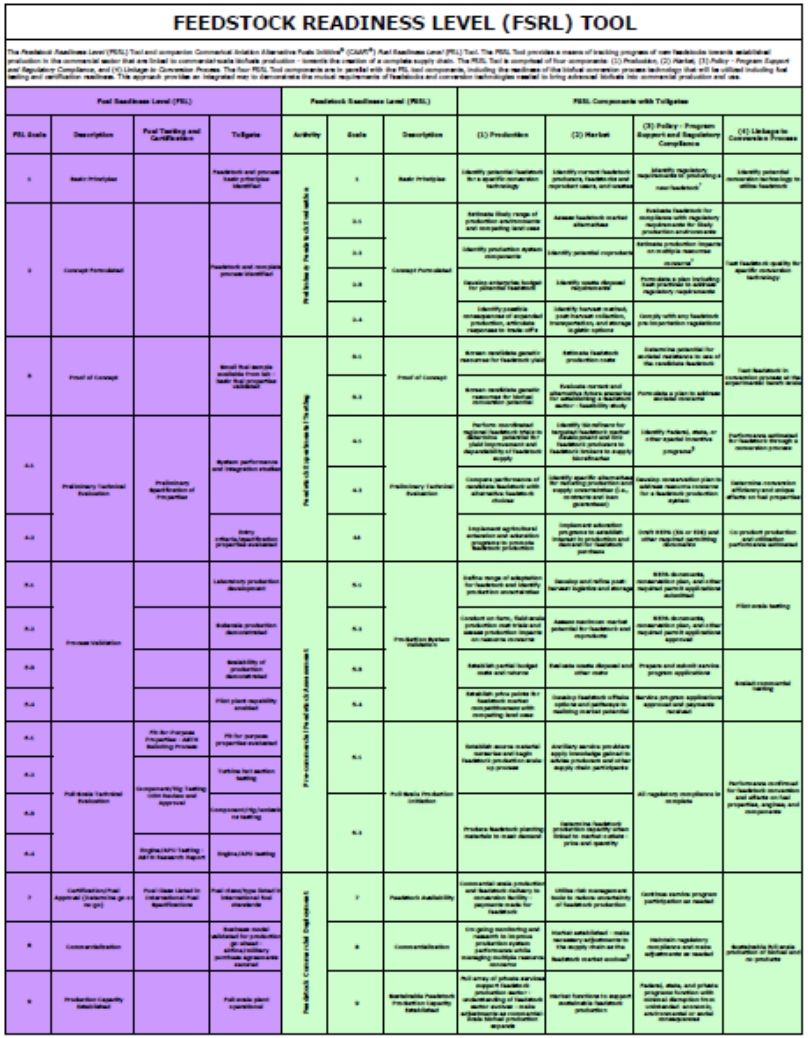
Feedstock Readiness Level



FEEDSTOCK READINESS LEVEL (FSRL) TOOL

Fuel Readiness Level (FRL)				Feedstock Readiness Level (FSRL)			FSRL Components with TriGates			
FRL Scale	Description	Fuel Testing and Certification	TriGate	Activity	Scale	Description	(1) Production	(2) Market	(3) Policy - Program Support and Regulatory Compliance	(4) Linkage to Conversion Process
1	Basic Principles		Feedstock and process basic principles identified	Feedstock Identification & Initial Viability Assessment	1	Basic Principles	Identify potential feedstock for a specific conversion technology	Identify current feedstock producers, feedstock end market users, and supply chain	Identify regulatory requirements of producing a new feedstock	Identify potential conversion technology to utilize feedstock
2	Concept Formulated		Feedstock and conversion process identified		2.1	Concept Formulated	Estimate likely range of production environments and competing land uses	Assess feedstock market alternatives	Evaluate feedstock for compliance with regulatory requirements for likely production environments	Test feedstock quality for specific conversion technology
					2.2		Identify production system components	Identify potential coproducts	Estimate production impacts on existing resource concerns	
					2.3		Develop enterprise budget for potential feedstock	Identify waste disposal requirements	Formulate a plan including best practices to address regulatory requirements	
					2.4		Identify possible management of expanded production, articulate responses to trade-offs	Identify harvest method, post-harvest collection, transportation, and storage logistic options	Comply with any feedstock pre-incorporation regulations	
3	Proof of Concept		Small test sample available from lab tests that properties validated	Feedstock Crop Variety Testing	3.1	Proof of Concept	Screen candidate genetic resources for feedstock yield	Estimate feedstock production costs	Determine potential for ecological tolerance to use of the candidate feedstock	Test feedstock in conversion process at the experimental bench scale
					3.2		Screen candidate genetic resources for biofuel conversion potential	Evaluate current and alternative future potential for establishing a feedstock sector - feasibility study	Formulate a plan to address ecological concerns	
4.1	Preliminary Technical Evaluation	Preliminary specification of properties	System performance and integration studies	Feedstock Crop Variety Testing	4.1	Preliminary Technical Evaluation	Perform coordinated regional feedstock trials to determine potential for yield improvement and dependability of feedstock supply	Identify biorefinery for potential feedstock market development and link feedstock producers to feedstock brokers to supply biorefineries	Identify Federal, state, or other coastal incentive programs[1]	Performance optimized for feedstock through a conversion process
					4.2		Compare performance of candidate feedstock with alternative feedstock choices	Identify specific alternatives for marketing production and supply uncertainties (i.e., in-season and loan guarantees)	Develop conservation plan to address resource concerns for a feedstock production system	Determine conversion efficiency and unique effects on fuel properties
4.2			Entry effects/specification properties evaluated		4.3		Implement agricultural extension and education programs to promote feedstock production	Implement education programs to establish interest in production and demand for feedstock purchase	Draft EIRs (EA or EIR) and other required permitting documents	Co-product production and utilization performance optimized
5.1	Process Validation		Laboratory production developed	Production System Validation	5.1	Production System Validation	Define range of adaptation for feedstock and identify production uncertainties	Develop and refine post-harvest logistics and storage	NEPA documents, conservation plan, and other required permit applications submitted	Pilot-scale testing
5.2			Materials production demonstrated		5.2		Conduct on-farm, field-scale production trials and assess production impacts on resource concerns	Assess maximum market potential for feedstock and coproducts	NEPA documents, conservation plan, and other required permit applications approved	
5.3			Reliability of production demonstrated		5.3		Establish partial budget costs and returns	Evaluate waste disposal and other costs	Prepare and submit service program applications	Related commercial testing
5.4			Pilot plant capability enabled		5.4		Establish price points for feedstock market development with competing land uses	Develop feedstock offtake options and partnerships to maximize market potential	Receive program applications approval and payments received	
6.1	Full-Scale Technical Evaluation	Fit for Purpose Properties - Add to Modeling Process	Fit for purpose properties estimated	Pre-commercial Feedstock Assessment	6.1	Full-Scale Production Limitation	Establish source material numbers and begin feedstock production-scale up process	Ancillary service providers apply knowledge gained in whole production and other supply chain participants	All regulatory compliance is complete	Performance confirmed for feedstock conversion and effects on fuel properties, engines, and components
6.2		Components/Fig Testing (OEM Review and Approval)	Turbine test section testing		6.2					
6.3			Component/Fig/emissions testing		6.3		Produce feedstock planting materials to meet demand	Determine feedstock production capacity often linked to market values price and quantity		
6.4		Engine/APU testing and in-research report	Engine/APU testing		6.4					
7	Certification/Fuel Approval (Determine go or no go)	Fuel Class Listed in International Fuel Specifications	Fuel class/type listed in international fuel standards	Feedstock Commercial Deployment	7	Feedstock Availability	Commercial-scale production and feedstock delivery to conversion facility - payments made for feedstock	Utilize risk management tools to reduce uncertainty of feedstock production	Continue service program participation as needed	Sustainably full-scale production of biofuel and co-products
8	Commercialization		Biofuel made available for production at select airline/military purchase agreements started		8	Commercialization	On-going monitoring and research to improve production system performances while managing multiple resource concerns	Market established - make necessary adjustments to the supply chain as the feedstock market evolves[2]	Maintain regulatory compliance and make adjustments as needed	
9	Production Capacity Established		Full-scale plant operational		9	Sustainable Feedstock Production Capacity Established	Full array of private services support feedstock production sector - understanding of feedstock sector evolves - make adjustments as commercial-scale biofuel production expands	Market functions to support sustainable feedstock production	Federal, state, and private programs function with minimal disruption to a sustainable economic, environmental or social consequence	

Readiness components

- Production
- Market
- Policy/Regulatory
- Linkage to conversion

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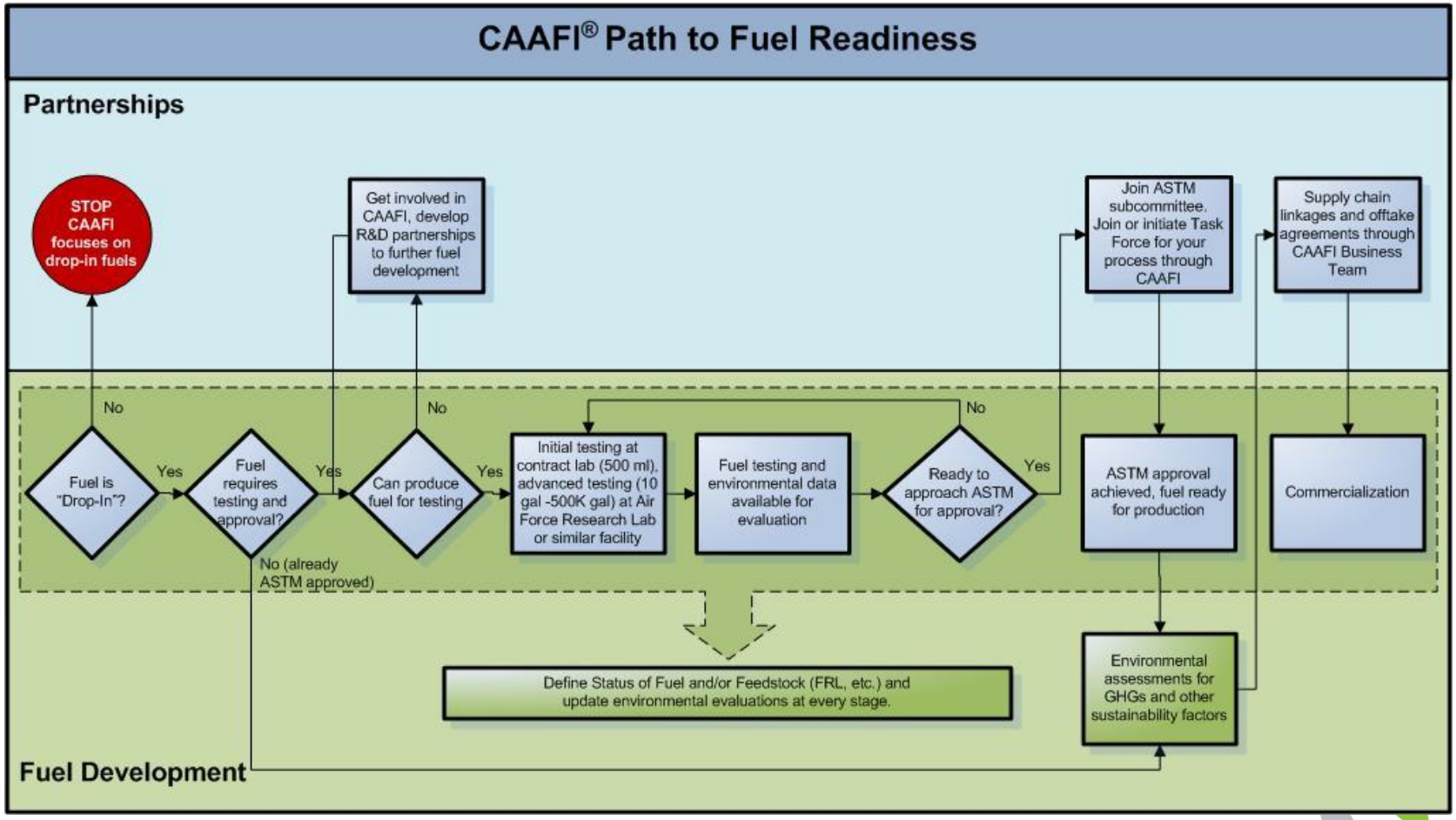
Path to Fuel Readiness



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Technology gap identification

- Concept proposed through membership input at 2011 Annual Meeting
- Solicited technology gaps/challenges from membership through mid-2012
- R+D team chairs “rolled-up” suggestions and drafted white papers
- Additional input gathered from gap proposers
- Drafts reviewed, revised, prioritized at R+D Team meeting, Dec 2012
- White papers in final review with R+D team membership
- Distribution Q2, 2012

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White papers on gap identification

Critical enablers requiring immediate development:

1) Flexible economic and engineering
2) Detailed analyses of fuel chemistry effects on fuel properties

R&D with near- and mid-term return on investment:

3) HEFA Feedstock cost reduction
4) Development of crosscutting
5) Feedstock production systems that incorporate diversity
6) Waste as feedstocks for alternative fuels

Sustained R&D on high benefit, low readiness level processes:

7) Direct collection and conversion of atmospheric CO2 to fuels

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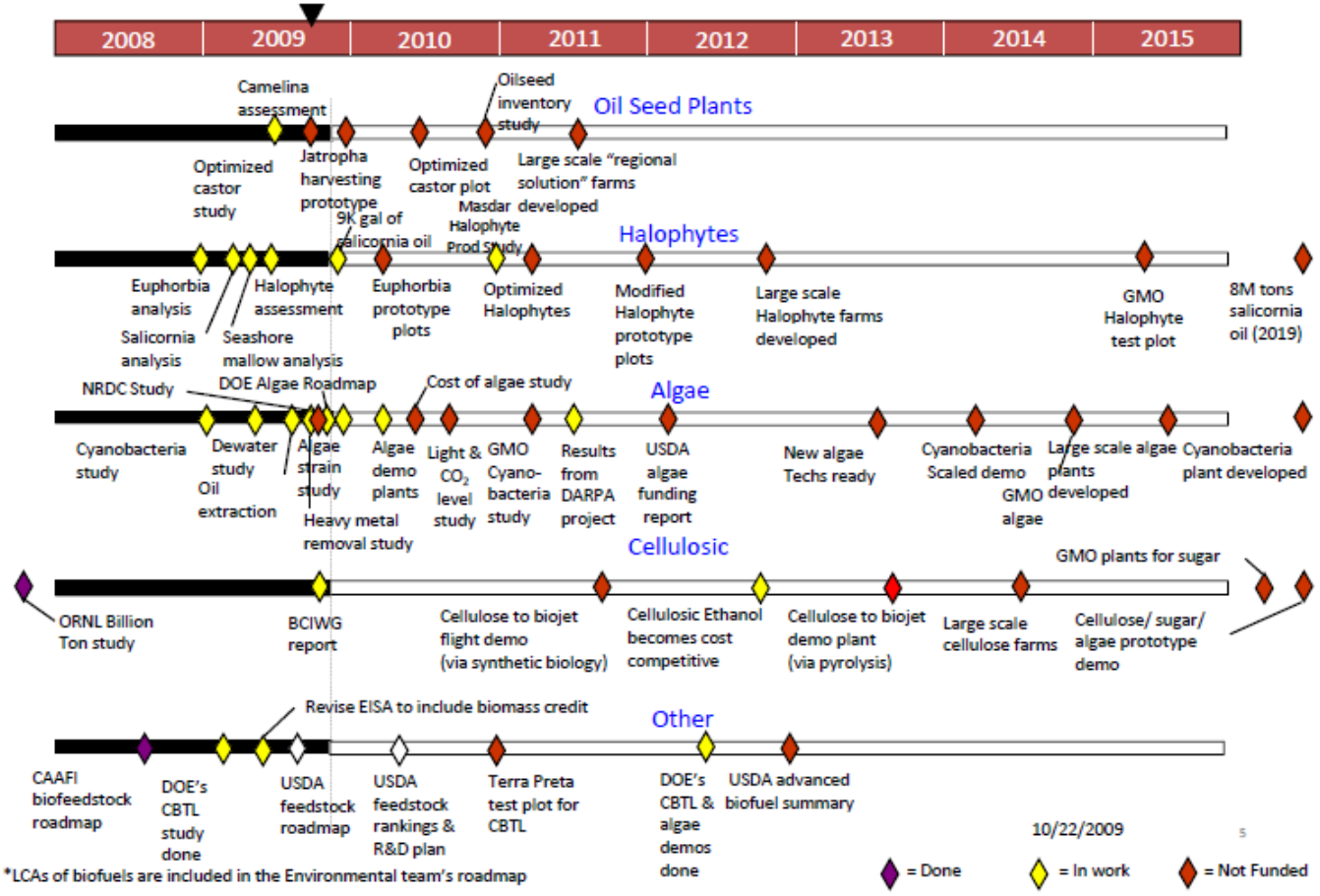
Refinement of Roadmap Tools

Level 3 ***Research and Development*** *(1 of 6)*

Feedstock



*LCAs of biofuels are included in the Environmental team's roadmap

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Thank you

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On behalf of

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