EAR 99 – Non-Proprietary

National Jet Fuels Combustion Program

Status Update

Jeff Moder, Ph.D.
NASA Glenn Branch Chief

Cecilia Shaw
FAA Program Manager

ASCENT Fall MEETING
October 10, 2018
Alexandria, VA

Expected Benefits

(from original Spring ASCENT Meeting 2015)

- Streamlines current ASTM approval process
- Reduces fuel quantities required for approval
- Reduces engine OEM risk/uncertainty
- Improved industry modeling and design tools

Accomplished Benefits

(present status)

- **Streamlines current ASTM approval process**
  - **Proposed tiered early screening process**
  - **Demonstration *in progress;***
    ***Major question:* How many iterations to convergence?**
- **Reduces fuel quantities required for approval**
  - ***"100 gallons, $100k" with Referee Rig***
  - ***May reduce Tier 3 and 4 tests (~3000 gallons)***
- **Reduces engine OEM risk/uncertainty for the approval of future alternative fuels**
  - **See OEM slides later**
    (*Referee Rig captures all OEM behavior)*
- **Improved industry modeling and design tools**
  - **Referee rig with new flow capability and procedures to characterize fuel-dependent blow out and ignition limits**
  - **LBO predictions using physical understandings capture trends well**
  - **CFD simulation tools for predicting LBO limits**

Three Major Results
since last meeting

1. **NJFCP has exceeded OEM expectations**
2. **NJFCP testing will being done in parallel to current D4054**
3. **NJFCP property rules are now included in DOE programs for prescreening**

- **Additional outreach/dissemination:**
  - **DOE**
  - **JetScreen**
  - **ABLC**
  - **CAAFI**
  - **CRC**
  - **Draft Book completed**
    - **10 out of 12 chapter drafts completed**
  - **AIAA Year in review**
  - **Technical Conferences (Combustion Inst., AIAA, ASME, and more)**

OEMs: *EXPECTATIONS EXCEEDED*

Major Result 1

OEM expectations from 2015 vs 2018 status

- **SUCCESS – If the OEM team, over the course of the program, gains insight and broadens an understanding of fuel effects on combustion** ✓
  - **e.g., LBO dependence on cetane number & pyrolysis products, ignition dependence on volatility, blending impact on FOMs, droplet volatility rather than spray variations affect LBO/ignition, etc.**
- **EXCEEDS EXPECTATIONS – If the program team develops tools/models that show the ability to simulate fuel effects and trends seen in the experiments chosen in the current program** ✓
  - **some modeling efforts already predict LBO trends – more work needs to be done to achieve repeatable high-confidence simulations, and OEM implementation**

OEMs: *then and now*
Major Result 1

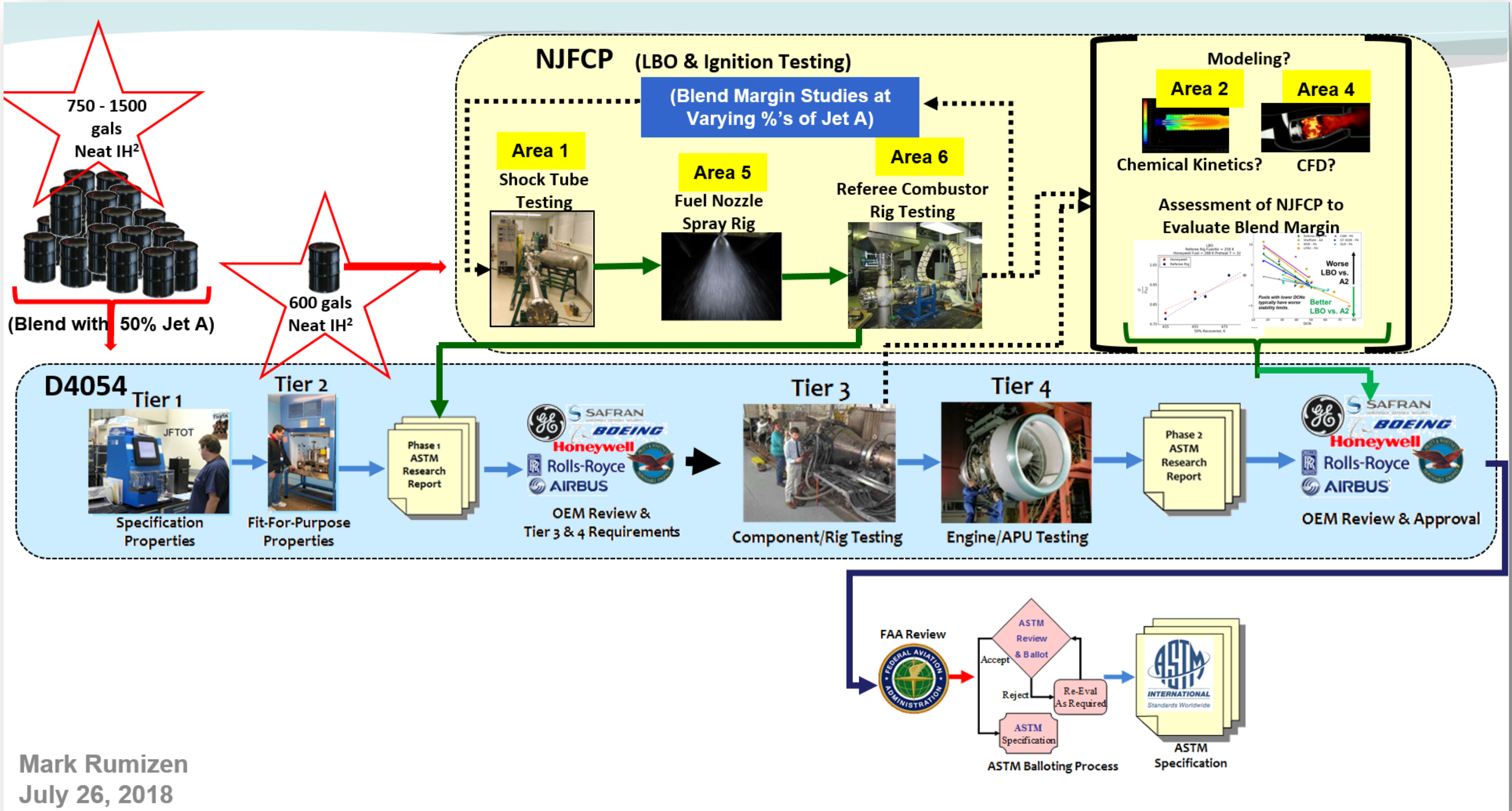
OEM perspective on state-of-the-art

OEMs place high value on insights gained and broadened understanding of fuel effects on combustion – NJFCP insights could help new fuel approvals as well as engine & combustor design efforts:

then	now
Don't know if generic design rigs could capture operability fuel trends compared to actual product rigs.	Generic combustor rigs (e.g., the referee rig) could capture operability trends with good confidence, and be used in fuel screening.
Ignition might depend on Cetane # (CN).	Instead, LBO strongly depends on CN. Could be used as an early predictor.
Don't know what pyrolysis yields are, and if they correlate to combustor operability.	Know the pyrolysis products. Yields can be used to build chemical models. Yields seem to correlate to combustor operability and might even be used to directly predict performance.
Ignition's dependence to properties is not clearly understood.	Ignition at altitude & low temperature depends primarily on viscosity.
Don't know if volatility or spray size variations has more effect?	Volatility affects operability more.
Don't know if unusual fuel compositions would lead to fuel effects when blended with jet if the carbon distribution is within kerosene range.	They could lead to behavior outside of conventional fuel experience even if carbon distribution is within kerosene range.
Sprays thought to likely be quite distinct for different fuels when using state-of-the-art air-blast injectors at room temperature.	Sprays are nearly identical.
Don't know if the conventional component washes-out the effects of an unusual blend component.	Blending "averages" the effects of the conventional and the unusual blend component.
Don't know if LES modeling could be used to predict LBO.	LES is capable of achieving LBO near experimental values, but very sensitive to boundary conditions. LES modeling of LBO is very slow.
No prior knowledge on IR absorption ratio relevance to combustion behavior.	IR absorption ratio correlates well with CN & ignition delay time, and possibly with operability behavior.
Surface tension's role for ignition is minimal to none.	Surface tension might be a stronger player than originally thought.

IH² Integrated NJFCP-D4054 Testing
Major Result 2

Focus of Year 5 NJFCP – IH² testing



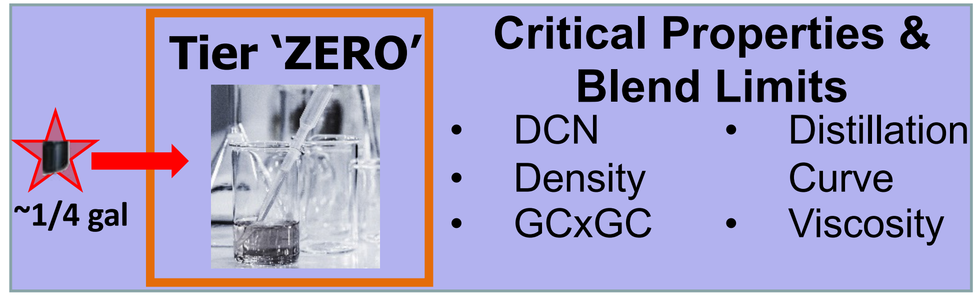
Mark Rumizen
July 26, 2018

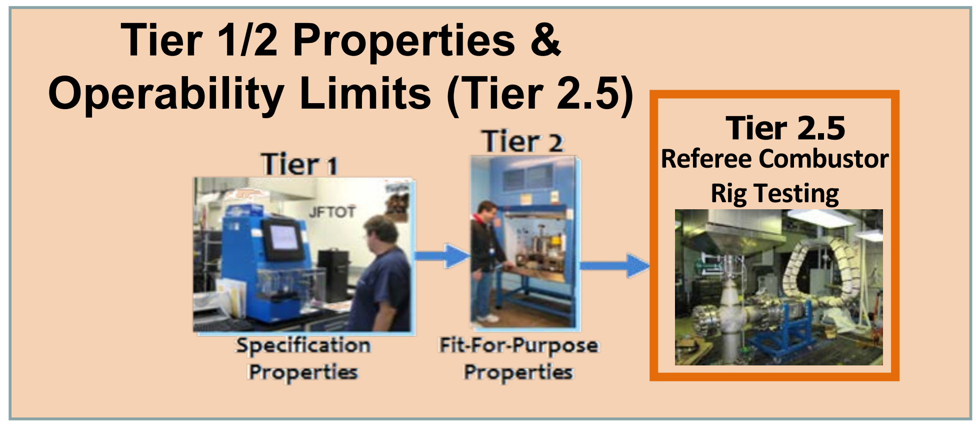
DOE Programs
Major Result 3

Awards Announced For Several Programs ($+12 million)

- ***Pre-screening*** **(Tier α and 0) and Tier 2.5 (Referee Rig) testing is required**
- **sites.udayton.edu/alternative-jet-fuel/**

Pre-screening





JET Program

- **Monetization on the benefit of High Performance SAJF (HPFs) on flight mission performance.**

NJFCP: Program Budget and Contributors

Agency	$K				
	Year-1	Year-2	Year-3	Year-4	Year-5
FAA*	2500	1353	2000	950	843
NASA	-	1103	1315	1,300	560
AFRL**	1971	1650	1000	1,000	500
DLA Energy	750	500	500	500	tbd
NavAir	200	200	400	200	200
ARL				650	tbd
Grand Total	**5421**	**5191**	**5215**	**4600**	

**OEMs are supporting program through cost-share.*
***AFRL spends additional funds (that are not included here) to procure/distribute fuels and develop/maintain rig.*

Additional Synergies:

- **DOE (in-house activities at National Labs, $12 million announced in jet fuel programs, & possible planned activities)**
- **AFOSR (in-house activities)**
- **NASA (in-house activities)**
- **NIST (in-house activities)**
- **NRC Canada (in-house activities)**
- **DLR (In-house activities, JetScreen Program)**
- **Univ. Sheffield (in-house activities, JetScreen Program)**
- **Cambridge Univ. (in-house activities)**
- **Univ. South Carolina (Supported by AFRL and NASA)**
- **Univ. of Toronto (in-house activities)**
- **Univ. of Dublin (in-house activities)**

National Jet Fuels Combustion Program (NJFCP)

Projects 25-30, 34

Project manager: Cecilia Shaw, FAA

Meredith Colket, Contractor

Joshua Heyne, University of Dayton

October 10, 2018
Alexandria, VA

OEMs: *NJFCP IMPACT HIGHLIGHTS*

OEM perspective on state-of-the-art

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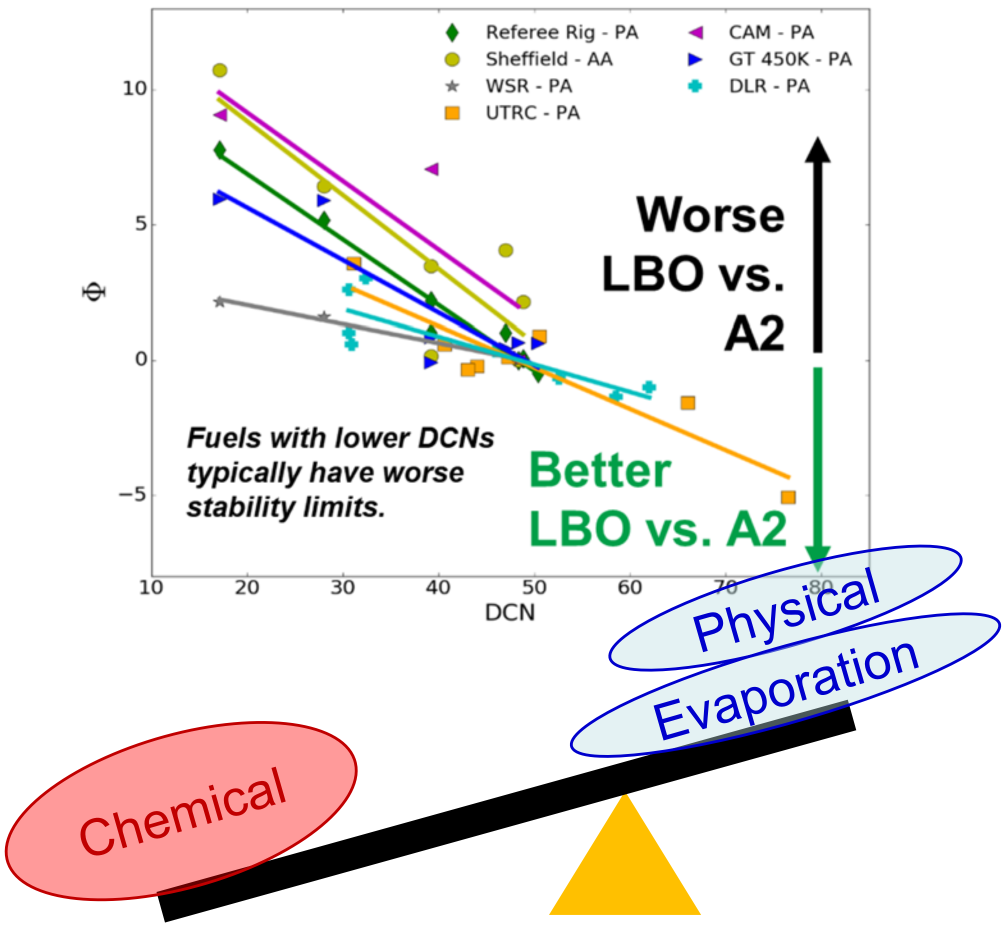
LBO Review:
Fuel Effects Dependent on Conditions and Engine Design

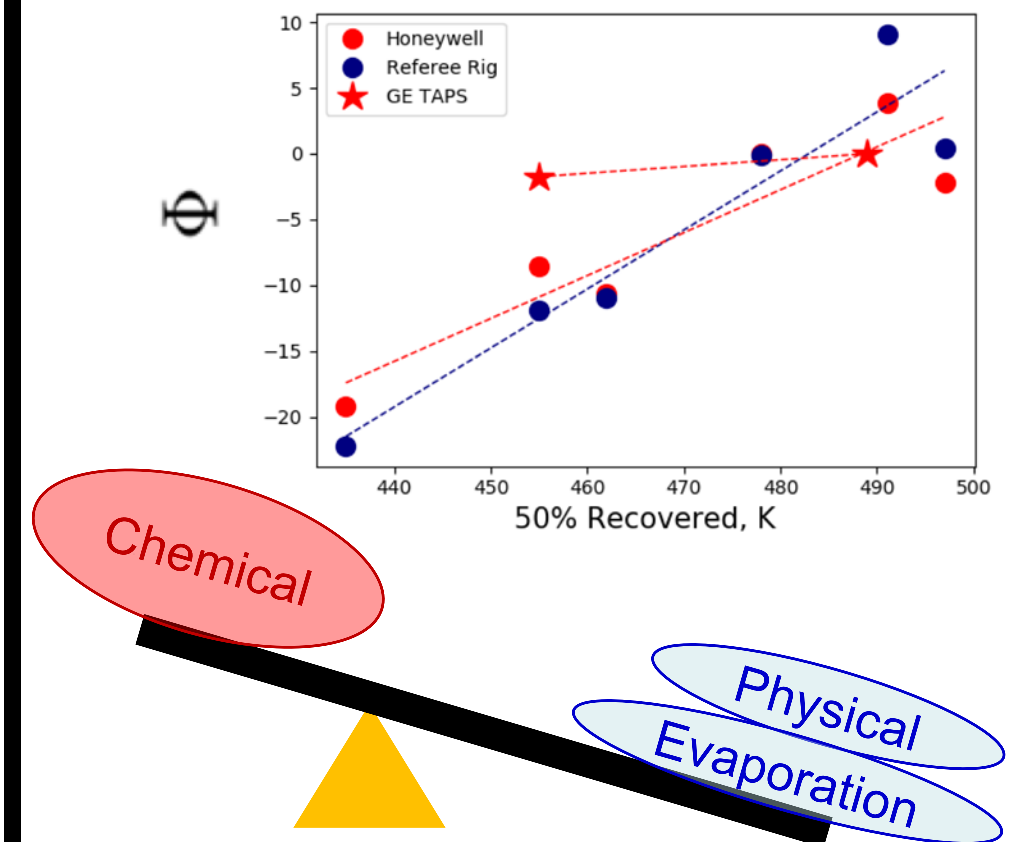
Chemical Limited:

- DCN dominance



Physical Property Limited:

- Distillation curve dominance

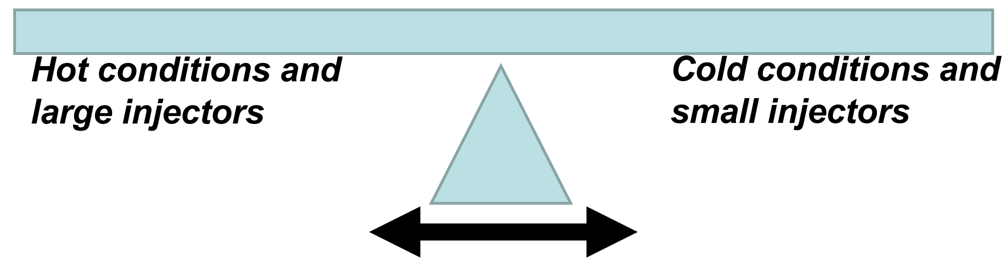


Updates since Last Meeting

Two Dominant Regimes

LBO results explained with 4 fuel properties

Chemical Properties | **Physical Properties**



Inlet conditions and geometry

Major Assumption:

- Statistical Sensitivity ~ physical τ

$\tau_{breakup} \sim \rho$

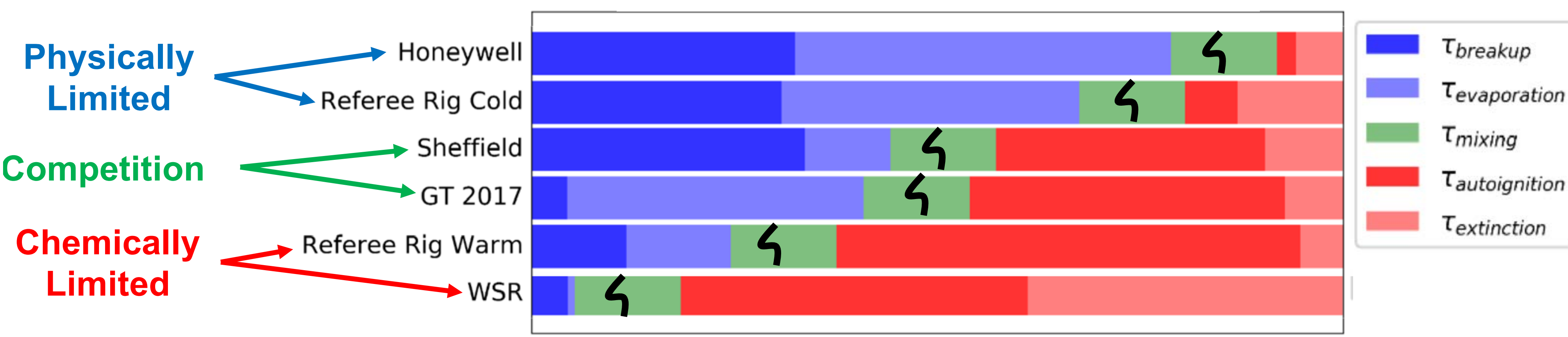
$\tau_{droplet} \sim T_{20}$

$\tau_{mixing} \cong constant$

$\tau_{extinction} \sim 1/Radical\ Index$

$\tau_{autoignition} \sim DCN$

Relative Statistical Sensitivity

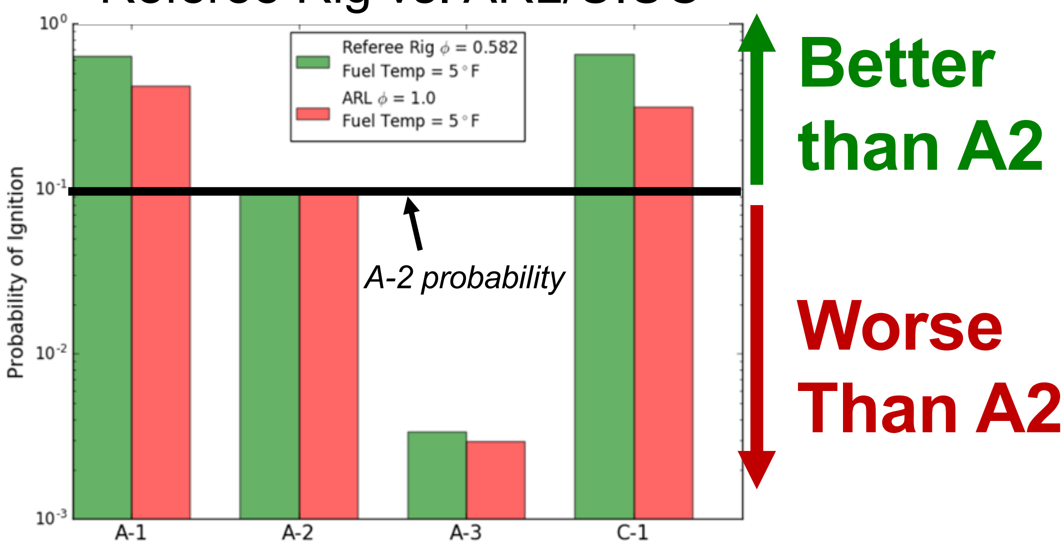


Scaled total time

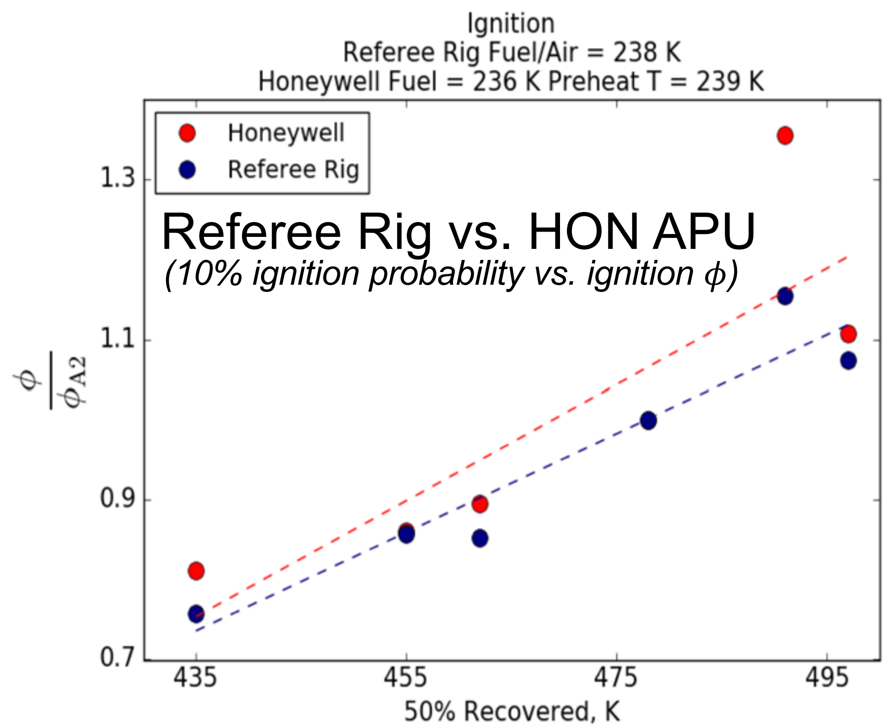
Ignition Review from Last Meeting

- **All results are consistent:**
  - **ARL/UIUC,**
  - **Referee Rig,**
  - **GT,**
  - **NRC Canada,**
  - **GE9X TAPS, and**
  - **HON APU**

Referee Rig vs. ARL/UIUC



Relative ignition probabilities, at a given $\phi_{A2}(P = 0.10)$ are nearly the same for the Referee Rig and the ARL rig.

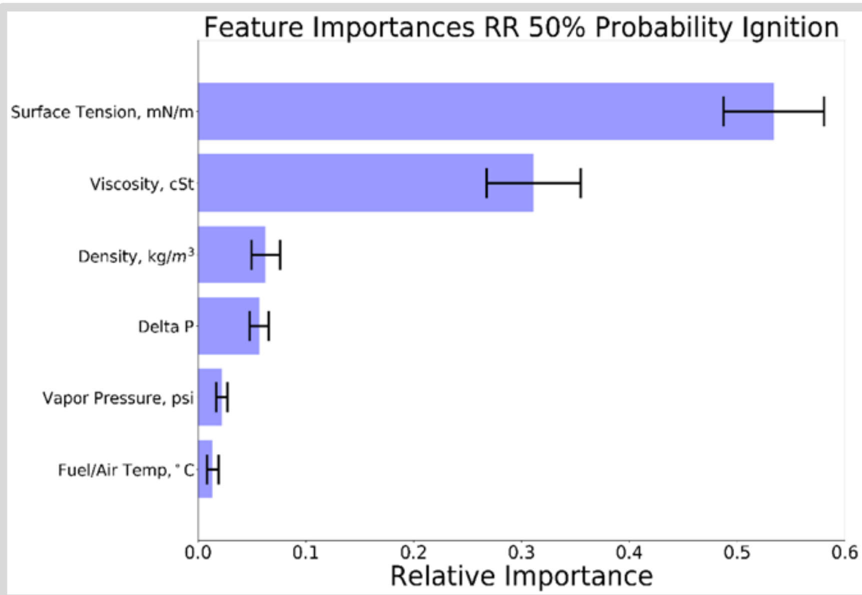


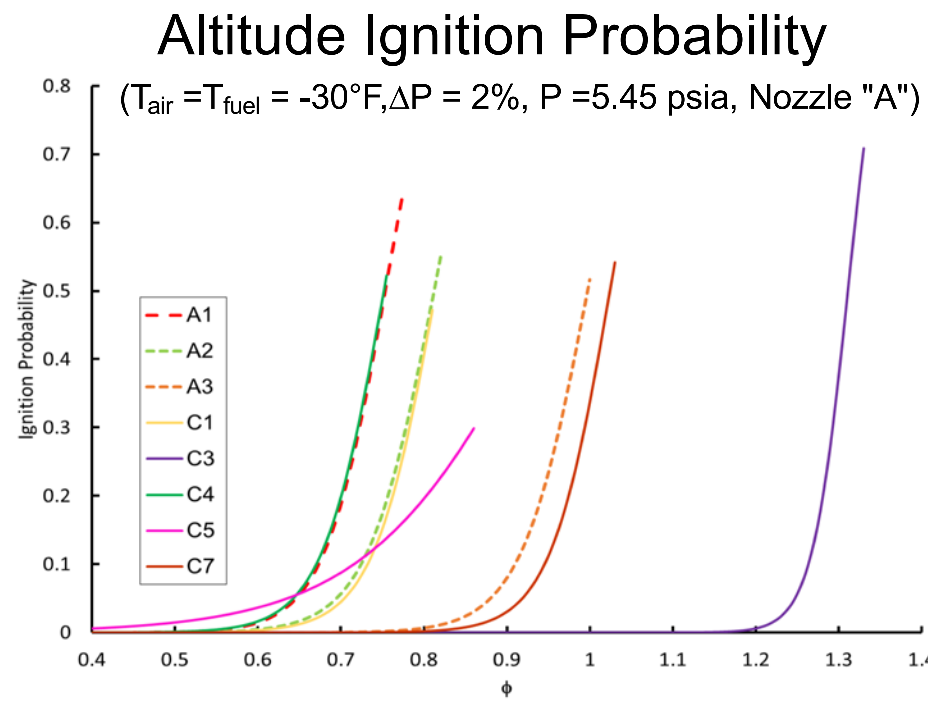
HON and Referee Rig show similar trends for the ignitability of fuels.

The distillation curve, not viscosity, is statistically the best predictor of ignitability.

Updates since Last Meeting

Referee Rig results show that differences in ignition performance is evident across fuels





Physical properties (viscosity and surface tension) are currently the most important factors in predicting ignition, *not* distillation temperatures (in contrary to prior conclusions).

The relative sensitivity of viscosity and surface tension is still an open.

- **Viscosity currently has two spec limits, -20 and -40 °C, included in the evaluation and approval process.**
- **There is no specification for surface tension, although surface tension is correlated to density which does have spec limits.**

CFD: LBO summary (Argonne/Purdue)

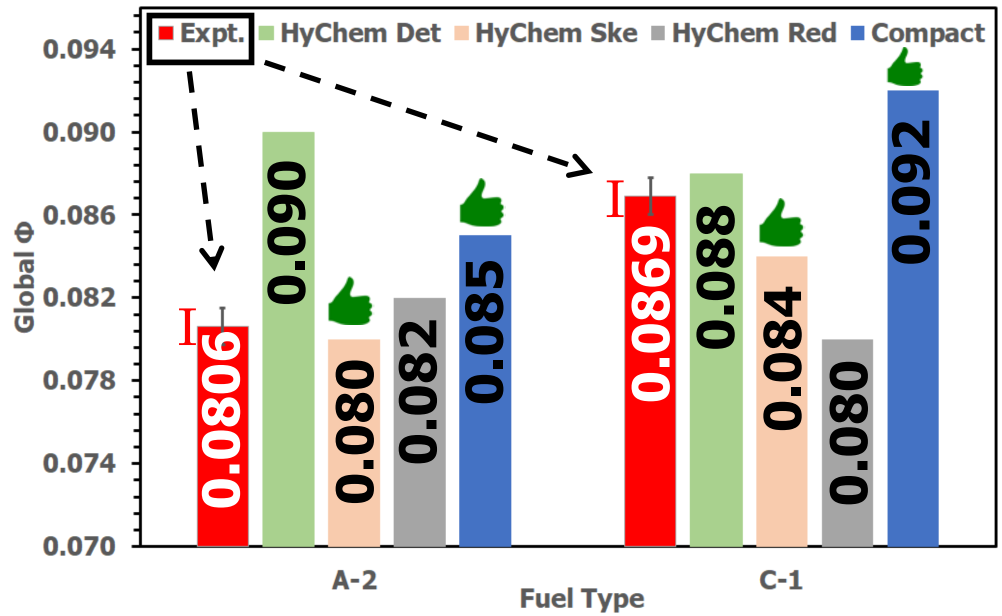
Correct trend with two kinetic mechanisms and nearly quantitative LBO, but opposite trend with other mechanisms

Mechanism	A-2 (#species)	C-1 (# species)
HyChem Detailed	**119**	**119**
HyChem Skeletal	**41**	**34**
HyChem Reduced	**31**	**26**
Compact Mechanism	**44**	**43**

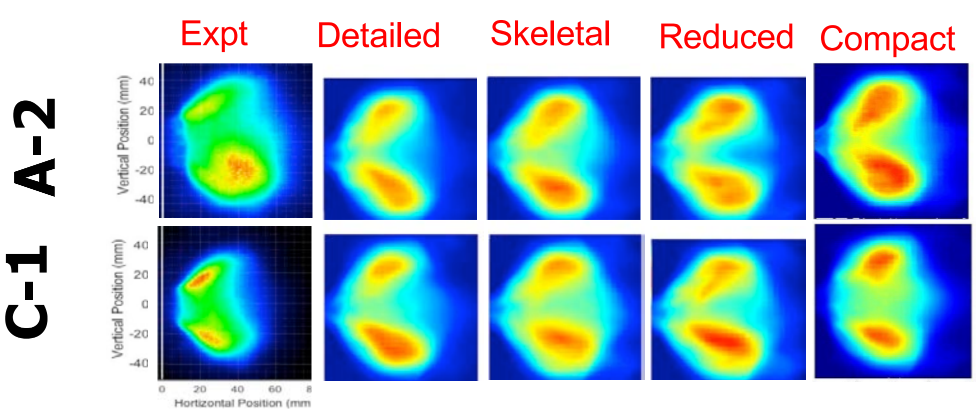
- A-2 fuel has a lower LBO limit compared to C-1
- HyChem skeletal and Won/Dryer compact mechanisms capture the LBO fuel trends

Reproduction of LBO limits

(Same code, grid and setup for all 4 mechanisms)



Flame Structure in reproduced



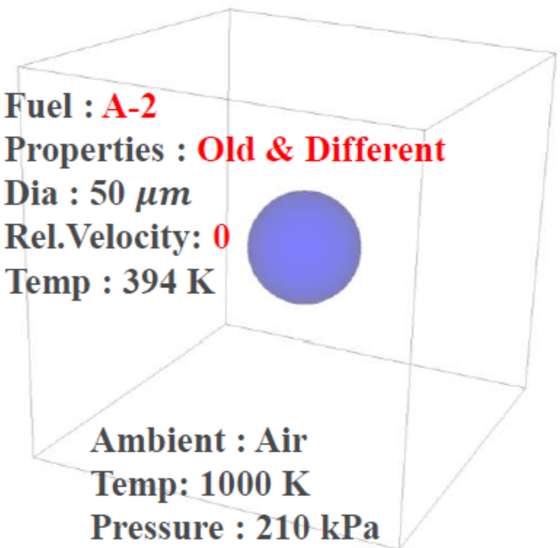
Near LBO
ϕ = 0.096

Expt: Avg OH*
LES: LOS Y_{OH}

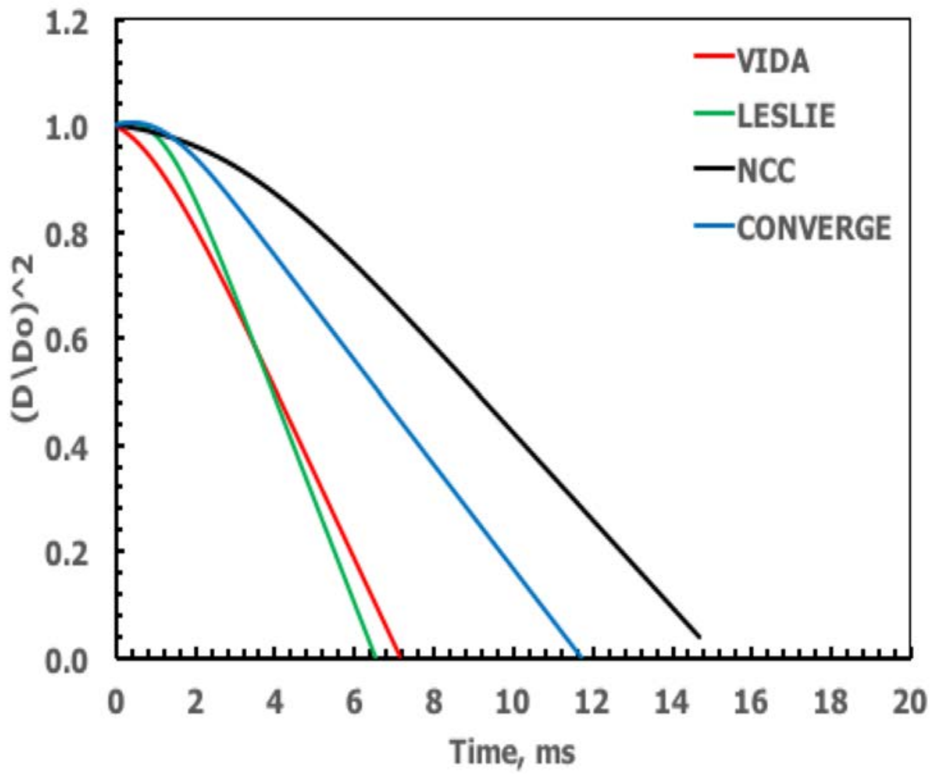
Impact of chemistry models and CFD solver numerics is under investigation

CFD: Consistency amongst models investigated
Vaporization model identified as one key difference

Stanford · Georgia Institute of Technology · Purdue University · United Technologies Research Center · Argonne National Laboratory



Droplet lifetimes vary as much as x2.5



Drop vaporization rates have first order impact on flame position.

In process of implementing comparable models and exploring other differences

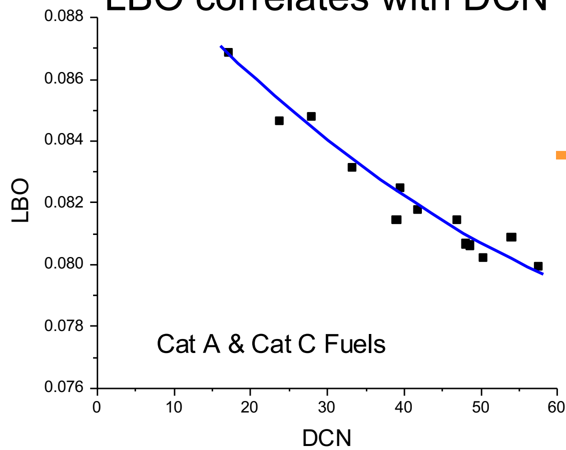
	VIDA	OpenNCC	LESLIE	CONVERGE
Evaporation Model	Miller Model[1]	Raju-Sirignano[2]	Faeth Model[3,4]	Frossling Model[5]

[1] R. Miller, K. Harstad, J. Bellan, Evaluation of equilibrium and non-equilibrium evaporation models for many-droplet gas–liquid flow simulations, Int. J.Multiphase Flow 24 (6) (1998) 1025–1055.
[2] M.S. Raju and W.A. Sirignano, ``Multi-Component Spray Computations in a Modified Centerbody Combustor," Journal of Propulsion and Power, Vol. 6, No. 2, March-April 1990
[3] G. M. Faeth. Evaporation and combustion of sprays. Progress in Energy and Combustion Science, 9(1-2):1{76, 1983.
[4] G. M Faeth. Mixing, transport and combustion in sprays. Progress in Energy and Combustion Science, 13(4):293{345, 1987.
[5] Frossling. N., 1938, Über die Verdüngtung fallenden Tropfen Gerlands Beiträge für Geophysik, 52 (1938), pp. 170-215

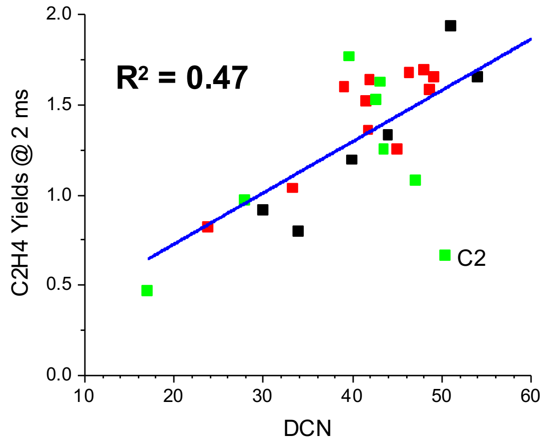
Kinetics: Hints at Simple Method for Assessing LBO Limits in a Shock Tube

UCONN Stanford

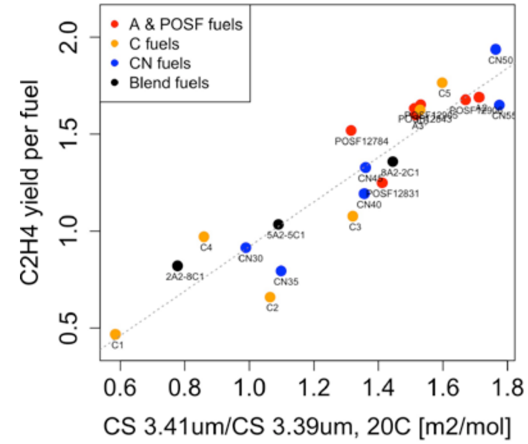
LBO correlates with DCN



DCN correlates with C2H4

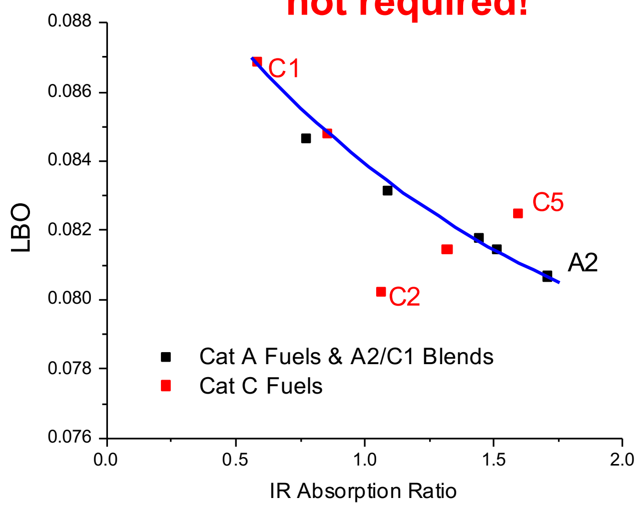


C2H4 correlates with IR ratios of raw fuel



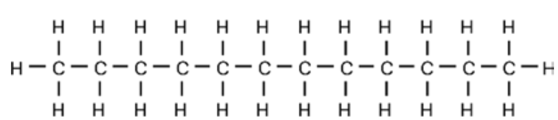
IR ratios correlate with LBO!!!

Shock tube experiments not required!

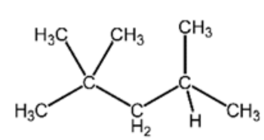


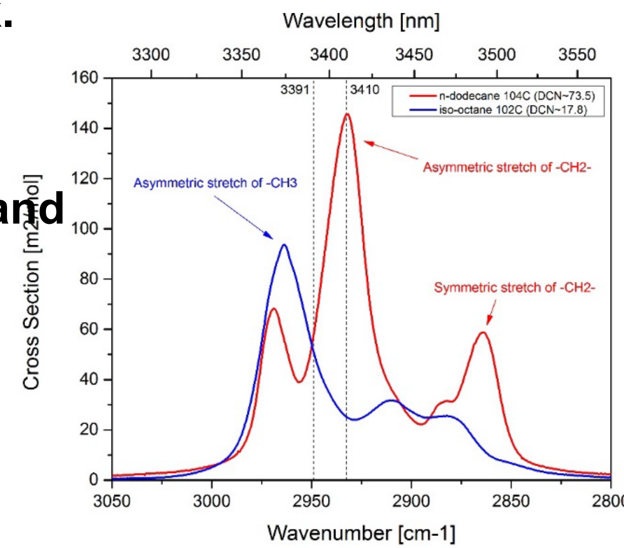
Explanation: IR spectra based on structure of fuel molecules (ex. CH2 vs. CH3). CH2 produces C2H4, CH3 produces CH4 and iso-butene. These molecules contrarily impact the kinetics and combustion processes.

N-dodecane



Iso-octane





Tiered Screening/Approval

Pre-Screening

Tier α

mLs

Property Predictions & Blend Estimations

- GCxGC,
- IR absorption, and/or
- NMR

Tier 'ZERO'

~1/4 gal

Critical Properties & Blend Limits

- DCN
- Density
- Distillation Curve
- Viscosity
- Surface Tension

ASTM D4054

200 gals (100 Tier 1&2, 100 Tier 2.5)

Tier 1

Specification Properties

Tier 2

Fit-For-Purpose Properties

Tier 2.5
Referee Combustor Rig Testing

Phase 1 ASTM Research Report

GE, SAFRAN, BOEING, Honeywell, Rolls-Royce, AIRBUS

OEM Review & Tier 3 & 4 Requirements

0? gals

Tier 3

Component/Rig Testing

Tier 4

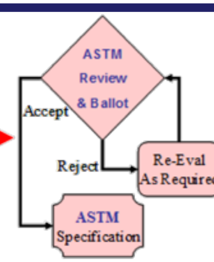
Engine/APU Testing

Phase 2 ASTM Research Report

GE, SAFRAN, BOEING, Honeywell, Rolls-Royce, AIRBUS

OEM Review & Approval

FAA Review



ASTM Balloting Process

ASTM Specification

Tier	$\mathcal{O}$(gal)
α	~10^{-4}
'ZERO'	~10^{-1}
1 & 2	~10^{2}
2.5	~10^{2}
3 & 4	~10^{3}

Overall NJFCP Accomplishments Fall 2018

Expected, Previously, and Recently Completed

- Hybrid Chemistry (HyChem) models (and their reduction to ~35 species) created and demonstrated for petroleum fuels and several NJFCP test fuels.
- Developed CFD models to predict fuel-dependent LBO limit trends
- Consistent fuel dependencies of Referee Rig with OEM facilities
- Method developed for time scale coupling for LBO limit interpretation
- Additional analysis of ignition results
- Demonstration of new screening method for IH^2 Fuel
- Explain variations in CFD modeling predictions for LBO limits
- Complete draft of book
- Further exploration of IR-LBO correlation
- Refine pre-screening and screening process

Individual Group Updates (1 of 5) - LBO Summaries and Next Steps

Referee Rig:
- Cold ignition conditions show dependence on surface tension and distillate properties for blowoff
- LBO experiments with additional geometry
- Additional LBO test conditions (T, P, and dP/P)
- Exploring the transition between Cetane-dominated fuel influences and physical property-dominated fuel influences

Georgia Tech:
- DCN is dominant LBO correlator/physical properties important at low T
- Evidence of preferential vaporization
- Evidence of local extinction-re-ignition stage that should be visible in CFD near LBO

GE CLEEN II:
- Virent HDO-SAK testing of SPK/SAK/Jet A blends in Q1-19

Sheffield:
- LBO trends similar to other rigs
- DCN additive shows similar LBO trends

Oregon State:
- Collaboration with GaTech to use flame data to evaluate chemistry modeling for A2 and C1
- Turbulent statistics a potential metric to evaluate flame instabilities and perhaps initiation of LBO
- Measure turbulent flame speeds for surrogate fuels, C5 (subatmospheric), or other fuels of interest

Individual Group Updates (2 of 5) – Ignition Summaries and Next Steps

GE CLEEN II:
- Virent HDO-SAK testing of SPK/SAK/Jet A blends in Q1-19

Referee Rig:
- Differences in ignition performance is evident across fuels
- Test data shows viscosity is an important factor but there are other factors to consider
- Further analysis of kernel trajectory with MATLAB code

Cambridge
- Noticeable fuel effects on ignition probability:
  * For lean conditions (ϕ=0.8): C1 most difficult to ignite
  * For stoich. to rich conditions (ϕ=1, 1.4): C1 easiest to ignite
- Droplets generally detrimental to flame speed (ϕ=1,1.4). Flame speed may increase with d_{32} for lean conditions.

Georgia Tech:
- Results indicate time required to heat droplets to vaporization temperature(s) is most important fuel difference for transition from kernel to growing flame
- Finishing PDPA sets for A2; C3,5; and n-dodecane
- Prevaporized ignition modeling suggests improvements may be needed in HyChem model for C5

Area 7:
- Surface tension and viscosity properties are currently the most important
- Constraints do not exist for surface tension, but already do for viscosity
- Design additional experiments to stress test dominant property hypothesis and orthogonalize property variations
- Investigation of various molecular groups with surface tension and viscosity

Individual Group Updates (3 of 5) - CFD Summaries and Next Steps

Argonne/Purdue:
- LBO Simulations for several versions of kinetic models utilized with some mixed results
- Good quantitative agreement and trends observed for two sets of models
- Caused for differences under evaluation

Stanford:
- Stable flame for A2 and C1 at phi=0.096
- LBO not achieved for A2 or C1. Small region of flame within swirl cup for phi as low as 0.035

Georgia Inst of Technology:
- Stable flame for A2 and C1 at phi=0.096
- LBO not achieved for A2 for phi as low as 0.07. Similar result expected for C1. Small region of flame within swirl cup

UTRC
- Providing spray initial conditions to all teams
- Providing consulting to other teams

NASA Glenn:
- Simulations underway, LBO not yet achieved
- Duplicating ability to generate HyChem kinetics model for C-4 fuel

UDRI/Williams:
- Simulations using commercial CFD software in progress
- Including evaluation of NJFCP-developed CFR codes

Individual Group Updates (4 of 5) – Kinetics Summaries and Next Steps

Stanford (Area 1):
- Developed multi-wavelength method for detecting multiple species, resulting in high (>80%) carbon mass recovery
- Applied method to petroleum fuels and to C-4
- Developing HyChem model for C-4
- Identified rapid fuel screening method based on IR absorption ratios
- Documentation in progress
- Will apply methods to IH^2 assessment in 2019

Stanford (Area 2):
- Refined base HyChem models based on updated small molecule chemistry
- Documented HyChem model as applied to petroleum fuels, C-1 and blends

Univ. of Connecticut (Area 2.5)
- Reapplied kinetic model reduction to updated models, including blend A-2/C-1 blend
- Demonstrated rapid and direct method for determining stirred reactor extinction limits
- Applied explosive mode analysis tools to CFD solutions to understand spatial distribution of critical reaction regions
- Recently developed method to reduce kinetic model to >20 species; utility TBD
- Will be developing reduced models for C-4

Univ. of Dayton (Area 7):
- Determining chemical times for LBO limit analysis

AFRL:
- Determined product distributions during lower temperature pyrolysis and correlated to LBO
- Starting series of shock tube pyrolysis studies

Individual Group Updates (5 of 5) – Spray Summaries and Next Steps

Purdue:
- Transitioning spray rig into new facility with advanced diagnostics
- Will measure fuel-dependent spray characteristics at conditions emulating referee rig ignition
- Will test IH^2 fuel in 2019 at all relevant test conditions

Nader Rizk:
- Applied spray modeling techniques to first ever data sets at sub-ambient conditions
- Refining and documenting spray modeling methods

Referee Rig:
- TBD

ARL Altitude Chamber
- Spray diagnostics to be applied to altitude chamber test during combustion

NRC Canada:
- Supporting book chapter development

Presentations and Publications

- **Conference Proceedings/Presentations: 112**
  - **Area 1 (Stanford): 17**
  - **Area 2 (Stanford): 8**
  - **Area 2.5 (UConn & Georgia Tech): 8**
  - **Area 3 (Georgia Tech, Oregon St.): 17**
  - **Area 4 (Georgia Tech): 11**
  - **Area 4/5 (Stanford): 10**
  - **Area 5 (Purdue): 7**
  - **Area 6 (Dayton): 8**
  - **Area 7 (Dayton): 21**
  - **UIUC (Related non-NJFCP Funded): 3**
  - **Surrogates: 2**
- **Peer Reviewed Journal Publications:**
  - **Area 1 (Stanford): 2 paper**
  - **Area 2.5 (Uconn & Georgia Tech): 1 paper**
  - **Area 3: (GaTech): 3 papers**
  - **Area 4/5 (Stanford): 4 papers**
  - **Area 3/6 (UIUC): 1 paper**
  - **Area 6: 2 papers**
  - **Area 7: 1 paper**

RECENT:

- **US-Mexico-Canada Trilateral Biojet Workshop, Keynote.**
- **AIAA Year in Review**

Upcoming:

- **ABLC**
- **CAAFI**
- **JetScreen**

Presentations

1. **Davidson, D. F., Tugestke, A., Zhu, Y., Wang, S., Hanson, R. K.,** "Species time-history measurements during jet fuel pyrolysis," 30th International Symposium on Shock Waves, Paper 179, Tel Aviv, Israel, July 2015. (Conference Papers)
2. **Zhu, Y., Wang, S., Davidson, D. F., Hanson, R. K.,** "Shock tube measurements of species time-histories during jet fuel pyrolysis and oxidation," 25th International Colloquium on the Dynamics of Explosions and Reactive Systems, Paper 262, Leeds, UK, August 2015. (Conference Papers)
3. **D. Hernandez, D. Llanos, S. Banerjee and C. T. Bowman,** Flow Reactor Study of Combustion Characteristics of Jet and Rocket Fuels, presented at the 9th US National Combustion Meeting, 2015, Cincinnati, OH.
4. **Rock, N., Chterev, I., Smith, T., Ek, H., Emerson, B., Noble, D., Seitzman, J., Lieuwen, T.** "Reacting Pressurized Spray Combustor Dynamics, Part 1. Fuel Sensitivities and Blowoff Characterization" *Proceedings of the ASME Turbo Expo 2016, Seoul, South Korea*, 2016, *GT2016-56346*
5. **Chterev, I., Rock, N., Ek, H., Smith, T., Emerson, B., Noble, D., E. Mayhew, T. Lee, N. Jiang, S. Roy, Seitzman, J., Lieuwen, T.** "Reacting Pressurized Spray Combustor Dynamics, Part 2. High Speed Planar Measurements" *Proceedings of the ASME Turbo Expo 2016, Seoul, South Korea*, 2016, *GT2016-56345*
6. **Fillo, A., Blunck, D.,** "Effects of Fuel Chemistry and Turbulence Intensity on Turbulent Consumption Speed for Large Hydrocarbon Fuels," Western States Section of the Combustion Institute, Fall 2015.

Presentations

7. **Chterev, I., N. Rock, H. Ek, T. Smith, B. Emerson, D.R. Noble, E. Mayhew, T. Lee, N. Jiang, S. Roy, J. Seitzman, T. Lieuwen,** Simultaneous High Speed (5 kHz) OH-PLIF and Stereo PIV Imaging of Pressurized Swirl-Stabilized Flames using Liquid Fuels, Int. Symp. on Combustion 2016: Seoul, South Korea. In Review.
8. **Sforzo, B., Dao, H., Wei, S. & Seitzman, J.** "Liquid Fuel Composition Effects on Forced, Non-Premixed Ignition" Proceedings of the ASME Turbo Expo 2016, Seoul, South Korea, 2016, GT2016-56163
9. **A. Fillo, D. Blunck,** "Effects of Fuel Chemistry and Turbulene Intensity on Turbulent Consumption Speed for Large Hydrocarbon Fuels," Western States Section Meeting of the Combustion Institute, Provo, UT (2015).
10. **J. Bonebrake, A. Fillo, D. Blunck,** "Effect of Turbulent Fluctuations on Radiation Emissions from a Premixed Flame," Western States Section Meeting of the Combustion Institute, Provo, UT (2015).
11. **E. Zeuthen, D. Blunck,** "Radiation emissions from Turbulent Diffusion Flames Burning Large Hydrocarbon Fuels," Western States Section Meeting of the Combustion Institute, Provo, UT (2015).
12. **E. Zeuthen, D. Blunck,** "Radiation Characteristics of Turbulent Diffusion Flames Burning Alternative Aviation Fuels," 9th US Combustion Meeting, Cincinnati, OH (2015).

Presentations

13. **Ranjan, R., Hannebique, G., Panchal A., and Menon, S.,** "Towards Numerical Prediction of Jet Fuels Sensitivity of Flame Dynamics in a Swirl Spray Combustion System", Accepted for presentation at the 2016 AIAA Propulsion and Energy Forum and Exposition, Salt Lake City, Utah, 25-27 July, 2016.

14. **Hannebique, G., Akiki, M., Ranjan, R., and Menon, S.,** "A Hybrid Eulerian-Eulerian/Eulerian-Lagrangian Method for Dense-to-Dilute Dispersed Multiphase Reacting Flows ", Accepted for presentation at the 2016 AIAA Propulsion and Energy Forum and Exposition, Salt Lake City, Utah, 25-27 July, 2016.

15. **Yang, S., Ranjan, R., Yang, V., Menon, S., and Sun, W.,** "Parallel on-the-fly adaptive kinetics in direct numerical simulation of turbulent premixed flame", Accepted for presentation at the 36th Combustion Symposium, Seoul, Korea, July 31- August 5, 2016.

16. **Esclapez, L., Nik, M.B., Ma, P.C., Carbajal, S., and Ihme, M.,** "LES of combustion dynamics near blowout in a realistic gas-turbine combustor." presentation at APS-DFD, Nov. 22-24, 2015, Boston.

17. **Ma, P.C., Esclapez, L., and Ihme, M.,** "Analysis of Fuel Injection and Atomization of a Hybrid Air-Blast Atomizer" presentation at APS-DFD, Nov. 22-24, 2015, Boston.

18. **Ma, P.C., Nik, M.B., Carbajal, S., Ihme, M., Buschhagen, T., Naik, S.V., Gore, J.P., Lucht, R.P.,** "Large-Eddy Simulations of Fuel Injection and Atomization of a Hybrid Air-Blast Atomizer" Presented at AIAA SciTech Meeting, San Diego, 2016.

Presentations

19. **Nik, M.B., Ma, P.C., Carbajal, S., and Ihme, M.,** "Characterization of Fuel Efects on Lean Blowout in Gas Turbine Combustors." Presented at AIAA SciTech Meeting, San Diego, 2016.
20. **Govindaraju, P., Wang, Q., Ihme, M.,** "Multicomponent Droplet Evaporation Using Group Contribution Methods" Presented at 9th US National Combustion Meeting, 2015, Cincinnati, OH.
21. **Stagni, A., Esclapez, L., Govindaraju, P., Cuoci, A., Favarelli, T., and Ihme, M.,** "The role of preferential evaporation on the ignition of multicomponent fuels in a homogeneous spray/air mixture." Accepted for presentation at Int. Symp. Combust, Seoul, 2016.
22. **T. Buschhagen, R. Z. Zhang, S. V. Naik, C. D. Slabaugh, S. E. Meyer, J. P. Gore, and R. P. Lucht,** "Effect of Aviation Fuel Type and Fuel Injection Conditions on Non-reacting Spray Characteristics of Hybrid Air Blast Fuel Injector," Presented at AIAA SciTech Meeting, San Diego, CA, 4-8 January 2016.
23. **P. C. May, M. B. Nik, S. E. Carbajal, S. Naik, J. P. Gore, R. P. Lucht, and M. Ihme,** "Large-Eddy Simulations of Fuel Injection and Atomization of a Hybrid Air-Blast Atomizer," Presented at AIAA SciTech Meeting, San Diego, CA, 4-8 January 2016.

Presentations

24. **E. Corporan, T. Edwards, C. Neuroth, D. Shouse, S. Stouffer, T. Hendershott, C. Klingshirn, M. DeWitt, S. Zabarnick, J. Diemer,** "Initial Studies of Fuel Impacts on Combustor Operability and Emissions at AFRL", Poster Presentation at IASH 2015, 14th International Symposium on Stability, Handling and Use of Liquid Fuels Charleston, South Carolina USA 4-8 October 2015.
25. **Stouffer, S.D., Hendershott, T.H., Monfort, J.R. , Corporan, E.,** Combustion Characteristics in a Single Cup Combustor Using Jet A and Research Fuels Paper for Central States Section of the Combustion Institute, Knoxville, Tennessee, May 15-17, 2016.
26. **J. S. Heyne, F. L. Dryer, S. H. Won, F. M. Haas,** "Reactivity Comparisons of Conventional and Alternative Jet Fuels in a Variable Pressure Flow Reactor" presented at 9th US National Combustion Meeting, 2015, Cincinnati, OH.
27. **J. S. Heyne, M. Colket,** "National Jet Fuels Combustion Program: Overall Program Integration and Analysis," CRC Aviation Committee Meetings, Nashville, TN, 6 May 2015.
28. **M. Colket, J. S. Heyne, M. Rumizen, J. T. Edwards, M. Gupta, W. M. Roquemore, J. P. Moder, J. M. Tishkoff, C. Li, et al.,** "An Overview of the National Jet Fuels Combustion Program," Presented at AIAA SciTech Meeting, San Diego, 2016.

Presentations (cont.)

29. **Stachler, R.D., Heyne, J.S., Miller, J.D., Stouffer, S.D., Zeppieri, S.P., Colket, M.B., Roquemore, W.M** "Well Stirred Reactor Emission Studies of Fuel Surrogates", Paper for Central States Section of the Combustion Institute, Knoxville, Tennessee, May 15-17, 2016.
30. **Bell, D., Heyne, J. S., Dryer, F. L., Won, S. H., Haas, F. M., Dooley, S.,** "On the development of fuel surrogates to match chemical, physical, and distillate properties," ASME DESS, Dayton, OH, November 2016.
31. **Stachler, R.D., Heyne, J.S., Miller, J.D., Stouffer, S.D., Roquemore, W.M** "Cross-Experiment Analysis of a Well-Stirred Reactor and other Gas Turbine Experiments", ASME DESS, Dayton, OH, November 2016.
32. **Carson, J., Heyne, J. S., Hendershot, T., Stouffer, S., Corporan, E.,** "Predicting LBO based on Random Forest Modeling," ASME DESS, Dayton, OH, November 2016.
33. **Lee, T.,** *Alternative Jet Fuel Database*, Federal Aviation Agency AEC Roadmap Meeting, Washington DC, May (2016).
34. **Xu, R., Chen, D., Wang H.** "Hybrid approach to combustion chemistry of jet fuels," poster presentation at the 36th International Symposium on Combustion, Seoul, Korea, July 31-August 5, 2016.
35. **Wang, H.,** "Key phenomena enabling direct simulation of real fuel combustion chemistry," 2015 PacifcChem Conference, Honolulu, Hawaii, December 18, 2015.

Presentations (cont.)

36. **Davidson, D. F., Zhu, Y., Wang, SJ., Parise, T., Sur, R., Hanson, R. K.,** "Shock Tube Measurements of Jet and Rocket Fuels," AIAA 2016-0178, *54th AIAA Aerospace Sciences Meeting*, San Diego CA, American Institute of Aeronautics and Astronautics, January 2016.
37. **Aaron Fillo, Jonathan Bonebrake, David Blunck,** "Sensitivity of jet fuel global consumption speed to fuel chemistry and turbulent intensity,“ 4P088 poster presentation at the 36th International Symposium on Combustion, Seoul, Korea, July 31-August 5, 2016.
38. **Chterev, I., Rock, N., Ek, H., Emerson B., Seitzman J., Jiang, N., Roy, S., Lee, T., Gord, T., and Lieuwen, T.** 2017. Simultaneous Imaging of Fuel, OH, and Three Component Velocity Fields in High Pressure, Liquid Fueled, Swirl Stabilized Flames at 5 kHz. Combustion and Flame. 186, pp. 150-165.
39. **Rock, N., Chterev, I., Emerson, B., Seitzman, J., and Lieuwen, T.,** Blowout Sensitivities in a Liquid Fueled Combustor: Fuel Composition and Preheat Temperature Effects. 2017. In ASME Turbo Expo 2017. GT2017-63305. Emerson managed the project.
40. **Wei, S., Sforzo, B. and Seitzman, J.** "High Speed Imaging of Forced Ignition Kernels in Non-Uniform Jet Fuel/Air Mixtures," 2017. Accepted for publication in Journal of Engineering for Gas Turbines and Power.

AIAA SciTech Presentations and Paper Submissions

41. **A. J. Bokhart, D. Shin, R. M. Gejji, P. E. Sojka, J. P. Gore, R. P. Lucht, S. V. Naik, and T. Buschhagen,** "Spray Measurements at Elevated Pressures and Temperatures Using Phase Doppler Anemometry," Paper 2017-0828, presented at the 55nd Aerospace Sciences Meeting, Grapevine, TX, 9-13 January, 2017.

42. Govindaraju, P., Esclapez, L., and Ihme, M., "Construction of Physical Fuel Surrogates using Computational Techniques," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

43. Esclapez, L., Ma, P. C., Mayhew, E., Xu, R., Stouffer,S.D., Lee, T., Wang, H., and M. Ihme, M., "Large-Eddy Simulations of Fuel Effects on Gas Turbine Lean Blow-out", AIAA Paper AIAA-2017-1955, AIAA SciTech Conference Jan 9-13, 2017.

Presentations (AIAA 2017 cont.)

44. **Davidson, D. F., Shao, J., Parise, T., and Hanson, R. K.,** "Shock Tube / Laser Absorption Measurements of Jet and Rocket Fuel Oxidation and Pyrolysis," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.
45. **Allison, P. M., Sidney, J. A. M., and Mastorakos, E.,** "Forced Response of Kerosene Flames in a Bluff-body Stabilised Combustor," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.
46. **Sidney, J. A. M., Allison, P. M., and Mastorakos, E.,** "The effect of fuel composition on swirling kerosene flames," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.
47. **Canteenwalla, P., and Chishty, W. A.,** "Investigation of Engine Performance at Altitude Using Selected Alternative Fuels for the National Jet Fuels Combustion Program," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

Presentations (AIAA 2017 cont.)

48. **Chtev, I., Rock, N., Ek, H., Smith, T., Emerson, B., Nobel, D. R., Seitzman, J., Lieuwen, T., Mayhew, E., Lee, T., Jiang, N., and Roy, S.,** "Simultaneous High Speed (5 kHz) Fuel-PLIE, OH-PLIF and Stereo PIV Imaging of Pressurized Swirl-Stabilized Flames using Liquid Fuels," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

49. **Edwards, J. T.,** "Reference Jet Fuels for Combustion Testing," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

50. **Stouffer, S.D., Hendershott, T.H., Monfort, J.R., Diemer, J. Edwin Corporan, E., Wrzesinski, P.J., Caswell, A.,** "Blowout and Ignition Characteristics of Conventional and Surrogate Fuels Measured in a Swirl Stabilized Combustor", AIAA Paper AIAA-2017-1954, AIAA SciTech Conference Jan 9-13, 2017.

Presentations (AIAA 2017 cont.)

51. **Sforzo, B., Wei, S., & Seitzman, J.** “Ignition of Alternative Liquid Jet Fuels in a Stratified Flow” 2017 AIAA Science and Technology Forum and Exposition, Grapevine, TX, 2017, AIAA-2017-0147
52. **Stachler, R. D., Heyne, J. S., Stouffer, S. D., Miller, J. D., and Roquemore, W. M.,** “Investigation of Combustion Emissions from Conventional and Alternative Aviation Fuels in a Well-Stirred Reactor,” *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.
53. **Temme, J., Kurman, M. S., and Kweon, C.-B. M.,** “Characterization of Alternative Jet Fuel Spray and Combustion at Engine Relevant Ambient Conditions,” *52nd AIAA/SAE/ASEE Joint Propulsion Conference*, Salt Lake City, UT: American Institute of Aeronautics and Astronautics, 2016.
54. **Temme, J., Colburn, V. D., and Kweon, C.-B. M.,** “High-speed chemiluminescence measurements of alternative jet fuels at engine relevant ambient conditions,” *Submitted to the 55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

Presentations (AIAA 2017 cont.)

55. **Yang, S., Ranjan, R., Yang, V., Menon, S., and Sun, W.,** "Parallel on-the-fly adaptive kinetics in direct numerical simulation of turbulent premixed flame," *Submitted to the 55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.
56. **Mayhew, E., Mitsingas, C., Mcgann, B., Hendershott, T. H., and Stouffer, S. D.,** "Spray Characteristics and Flame Structure of Jet A and Alternative Jet Fuels," AIAA Paper AIAA-2017-0148, *55th AIAA Aerospace Sciences Meeting*, American Institute of Aeronautics and Astronautics, 2017.
57. **Xu, R., Chen, D., Wang, K., and Wang, H.,** "A Comparative Study of Combustion Chemistry of Conventional and Alternative Jet Fuels with Hybrid Chemistry Approach," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.
58. **Bell, D., Heyne, J. S., Won, S. H., Dryer, F. L., Haas, F. M., and Dooley, S.,** "On the Development of General Surrogate Composition Calculations for Chemical and Physical Properties," *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

Presentations (AIAA 2017 cont.)

59. **Podboy, D. P., Chang, C., and Moder, J. P.,** “Lean Blowout Fuel Sensitivity for a Lean Direction Injection Combustor,” *55th AIAA Aerospace Sciences Meeting*, Grapevine, TX: American Institute of Aeronautics and Astronautics, 2017.

60. **Monfort,J.R., Stouffer, S.D,. Hendershott, T.H., Wrzesinski, P.J., Foley, W.S.,** "Evaluating Combustion Instability in a Swirl-Stabilized Combustor Using Simultaneous Pressure, Temperature, and Chemiluminescence Measurements at High Repetition Rates," AIAA Paper AIAA 2017-1101, AIAA SciTech Conference Jan 9-13, 2017.

ASME Turbo Expo 2017

61. "Blowout Sensitivities in a Liquid Fueled Combustor: Fuel Composition and Preheat Temperature Effects." Proceedings of the ASME Turbo Expo GT2017-63305

62. "Reacting Pressurized Spray Combustor Dynamics, Part 1. Fuel Sensitivities and Blowoff Characterization." Proceedings of the ASME Turbo Expo GT2016-56346

63. "Reacting Pressurized Spray Combustor Dynamics, Part 2. High Speed Planar Videos." Proceedings of the ASME Turbo Expo GT2016-56345

64. **S. Wei, B. Sforzo and J. Seitzman,** "High Speed Imaging of Forced Ignition Kernels in Non-Uniform Jet Fuel/Air Mixtures," GT2017-63300, Proceedings of the ASME/IGTI Turbo Expo 2017.

ASME Turbo Expo 2018

1. S. Wei, B. Sforzo and J. Seitzman, "Fuel Composition Effects on Forced Ignition of Liquid Fuel Sprays," GT2018-77196 Proceedings of the ASME/IGTI Turbo Expo 2018, June 11-14, 2018 Oslo Norway.

2. Y. Tang, M. Hassanaly, V. Raman, B. Sforzo, S. Wei and J. Seitzman, "Simulation of Gas Turbine Ignition Using Large Eddy Simulation Approach," GT2018-76216 Proceedings of the ASME/IGTI Turbo Expo 2018, June 11-14, 2018 Oslo Norway.

Peer Reviewed Archival Publications

1. **X. Gao, S. Yang, W. Sun,** "A global pathway selection algorithm for the reduction of detailed chemical kinetic mechanisms" Combustion and Flames, 2016 (doi:10.1016/j.combustflame.2016.02.007)
2. **D. Valco, K. Min, A. Oldani, T. Edwards, T. Lee,** *Low Temperature Autoignition of Conventional Jet Fuels and Surrogate Jet Fuels with Targeted Properties in a Rapid Compression Machine*, Proc. Comb. Symp. accepted (2016)
3. **Davidson, D. F., Zhu, Y., Shao, J., Hanson, R. K.,** "Ignition Delay Time Correlations for Distillate Fuels," Fuel 187 (2017) 26-32, DOI: 10.1016/j.fuel.2016.09.047P. Govindaraju and M. Ihme, Group contribution method for multicomponent evaporation with application to transportation fuels, Int. J. Heat & Mass Transfer, 2016, 102, 833-845
4. **A. Stagni, L. Esclapez, P. Govindaraju, A. Cuici, T. Favarelli, M Ihme,** The role of preferential evaporation on the ignition of multicomponent fuels in a homogeneous spray/air mixture, Proc. Comb. Inst., 2016
5. **H. Wu, M. Ihme,** Compliance of combustion models for turbulent reacting flow simulations, submitted to Fuel, 2016
6. **M. Colket, J. S. Heyne, M. Rumizen, J. T. Edwards, M. Gupta, W. M. Roquemore, J. P. Moder, J. M. Tishkoff, C. Li, et al.,** "An Overview of the National Jet Fuels Combustion Program," AIAA Journal, DOI: 10.2514/1.J055361.
7. **Escalpez,L., M, P.C., Xu, R., Stouffer, S.D. Lee, T., Wang, H., Imhe, M.,** "Fuel Effects on Lean Blow-out in a Realistic Gas Turbine Combustor, Accepted for Combustion and Flame (2017).
8. Briones, A.M., Stouffer, S.D., Vogiatzis, K., Rein, K., Rankin, B.A., Effects of Effusion and Film Cooling Jet Momenta on Combustor Flow Fields, To be published in J. Eng. Gas Turbines & Power, 2017.

OUTSIDE ENGAGEMENTS

10TH US NATIONAL COMBUSTION MEETING

1. **A. Panchal, R. Ranjan, S. Menon,** "Subgrid Mixing and Evaporation Modeling in Large Eddy Simulation of Two-Phase Reacting Flows," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
2. **M. E. Feyz, Razi Nalim, J. P. Gore, Ali Tarraf,** "Analytical study on near-field entrainment in a transient turbulent free jet," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
3. **Yujie Tao, Gregory P. Smith, Hai Wang,** "Uncertainty of a Foundational Fuel Chemistry Model," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
4. **Chao Xu, Muhsin M. Ameen, Sibendu Som, Jacqueline H. Chen, Tianfeng Lu,** "Dynamic adaptive combustion modeling of diesel spray flames based on chemical explosive mode analysis," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
5. **Robert D. Stachler, Joseph K. Lefkowitz, Timothy M. Ombrello, Scott D. Stouffer, Joshua S. Heyne, Joseph D. Miller,** "The effect of residence time on the ignitability of ethylene and air mixtures in a toroidal jet-stirred reactor," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

OUTSIDE ENGAGEMENTS

10TH US NATIONAL COMBUSTION MEETING

6. **Ji-Woong Park, Tianfeng Lu,** "Chemical explosive mode analysis on extinction of 1-D premixed counterflow flames," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
7. **Karla Dussan, Frederick L. Dryer, Sang Hee Won, Stephen Dooley,** "Predicting Real Transportation Fuel Combustion Properties: Distinct Chemical Functionalities in Hydrocarbon Laminar Burning Velocities," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
8. **Martin Rieth, Reetesh Ranjan, Suresh Menon, Andreas Kempf,** "On the Comparison of Finite-Rate Kinetics and Flamelet Base Subgrid Models for LES of Turbulent Premixed Flame," 10th US National Combustion Meeting, Maryland, April 23–26, 2017.
9. **Shengkai Wang, Thomas Parise, David F. Davidson, Ronald K. Hanson,** "A New Diagnostic for Hydrocarbon Fuels using 3.41-µm Diode Laser Absorption," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
10. **Michael Halloran, Nicholas Traina, Tonghun Lee, Jihyung Yoo,** "Measurements of low concentration hydrocarbons at elevated temperatures and pressures using supercontinuum laser absorption spectroscopy," 10th US National Combustion Meeting, Maryland, April 23-26, 2017.

OUTSIDE ENGAGEMENTS

10TH US NATIONAL COMBUSTION MEETING

11. **Jiankun Shao, Yangye Zhu, Shengkai Wang, David F. Davidson, Ronald K. Hanson,** "Shock Tube Study of Jet Fuel Pyrolysis and Ignition at Elevated Pressure," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
12. **Alison M. Ferris, David F. Davidson, Ronald K. Hanson,** "Combined Laser Absorption and Gas Chromatography (GC) Speciation in a Shock Tube: Validation and Application to Ethylene Pyrolysis," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
13. **Aaron W. Skiba, Campbell D. Carter, Stephen D. Hammack, Tonghun Lee,** " A simplified approach to multi-scalar imaging for turbulent premixed flames," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
14. **A.M. Tulgestke, D.F. Davidson, R.K. Hanson,** "Laser absorption measurements of ethylene and carbon monoxide time-histories during *n*-heptane oxidation at low temperatures behind reflected shock waves," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
15. **R. Xu, H. Wang, D. F. Davidson, R. K. Hanson, C. T. Bowman, F. N. Egolfopoulos,** "Evidence Supporting a Simplified Approach to Modeling High-Temperature Combustion Chemistry," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

OUTSIDE ENGAGEMENTS

10^{TH} US NATIONAL COMBUSTION MEETING

16. **R. Xu, D. Chen, K. Wang, Y. Tao, J. K. Shao, T. Parise, Y. Zhu, S. Wang, R. Zhao, D. J. Lee, F. N. Egolfopoulos, D. F. Davidson, R. K. Hanson, C. T. Bowman, H. Wang,** "HyChem Model: Application to Petroleum-Derived Jet Fuels ," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
17. **Pavan B. Govindaraju, Matthias Ihme,** "Sensitivity to Experimental Uncertainty in Surrogate Descriptions of Aviation Fuels," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
18. **Yang Gao, Tianfeng Lu,** "Reduced HyChem Models for Jet Fuel Combustion," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
19. **K. Wang, R. Xu, T. Parise, J. K. Shao, D. J. Lee, A. Movaghar, D. F. Davidson, R. K. Hanson, H. Wang, C. T. Bowman, F. N. Egolfopoulos,** " Combustion Kinetics of Conventional and Alternative Jet Fuels using a Hybrid Chemistry (HyChem) Approach" 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.
20. **K. Wang, R. Xu, T. Parise, J.K. Shao, D. F. Davidson, R. K. Hanson, H. Wang, C. T. Bowman,** "Evaluation of a Hybrid Chemistry Approach for Combustion of Blended Petroleum and Bio-derived Jet Fuels," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017

OUTSIDE ENGAGEMENTS

10TH US NATIONAL COMBUSTION MEETING

21. **Chao Xu, Tianfeng Lu,** "An iterative uncoupled quasi-steady-state method for dynamic chemical stiffness removal," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

22. **Xiang Gao, Wenting Sun,** "Using Global Pathway to Understand Chemical Kinetics," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

23. **Alex Krisman, Tianfeng Lu, Jacqueline H. Chen,** "A direct numerical simulation study of the quenching of jet fuel flame kernels subject to intense isotropic turbulence," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

24. **Giulio Borghesi, Jacqueline H. Chen, Alexander Krisman, Tianfeng Lu,**"Direct Numerical Simulation of a Turbulent Autoigniting-Dodecane Jet at Low- Temperature Diesel Conditions, 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

25. **Jeffrey Labahn, Peter C Ma, Lucas Esclapez, Mattias Ihme,** "Investigation of initial droplet distribution and importance of secondary breakup model on lean blowout predictions of a model gas turbine combustor," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

OUTSIDE ENGAGEMENTS

10TH US NATIONAL COMBUSTION MEETING

26. **Sang Hee Won, Francis M. Haas, Stephen Dooley, Frederick L. Dryer,** "Chemical Functional Group Descriptor for Jet Fuel Surrogate," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
27. **Jeffrey R. Monfort, Scott D. Stouffer, Tyler H. Hendershott, Edwin Corporan, Andrew Caswell,** "Experimental Characterization of Fuel-Dependent Resonance in a Representative Swirl Combustor," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
28. **Robert Zhang1, Andrew C. Pratt, Robert P. Lucht, Carson D. Slabaugh,** "Investigation of the Pilot Stagnation Region in a High Power Liquid-Fueled C Combustor," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
29. **R. Ranjan, A. Panchal, B. Muralidharan, S. Menon,** "Simulation of the Evolution of Premixed Flame Kernels in a Turbulent Channel Flow," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.
30. **Chiara Saggese1, Ajay V. Singh, Joaquin Camacho, Hai Wang,** "Effect of Distillate Fraction of Real Jet Fuel on Sooting Propensity – Part 1: Nascent Soot Formation in Premixed Stretch-Stabilized Flames," 10th US National Combustion Meeting, College Park, MD, April 23-26, 2017.

OUTSIDE ENGAGEMENTS

10TH US NATIONAL COMBUSTION MEETING

31. **Giacomo Flora, Moshan S. P. Kahandawala1, Matthew DeWitt, Edwin Corporan,** "Ignition Delay Measurements for Alternative Jet Fuels at Mid to Low Temperatures," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

32. **Kyungwook Min, Daniel Valco, Anna Oldani, Tonghun Lee,** "Autoignition Behavior of Jet Fuel Relevant Pure Hydrocarbon Components in a Rapid Compression Machine," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

33. **Utsav Jain, Chao Han, Haifeng Wang,** "Characteristics and Parameterization of Spray Combustion in Laminar Counter-flow Jet Flames," 10th US National Combustion Meeting, Maryland, April 23–26, 2017.

34. **Aaron J. Fillo1, Jonathan M. Bonebrake1, David L. Blunck,** "Impact of fuel chemistry and stretch rate on the global consumption speed of large hydrocarbon fuel/air flames," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

35. **Suo Yang1, Reetesh Ranjan, Vigor Yang, Wenting Sun, Suresh Menon,** "Sensitivity to Chemical Kinetics Models in Time-Evolving Turbulent Non-Premixed Flames," 10th US National Combustion Meeting, Maryland, April 23-26, 2017.

36. **Debolina Dasgupta, Wenting Sun, Marc Day, Tim Lieuwen,** "Sensitivity of chemical pathways to reaction mechanisms for *n*dodecane," 10th US National Combustion Meeting, Maryland, April 23-26, 2017.

OUTSIDE ENGAGEMENTS

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37. **Jacob Sebastian, Benjamin Emerson, Timothy Lieuwen,** "Stability Analysis of Multiple Reacting Wakes 10th US National Combustion Meeting," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

38. **Jeffrey O'Brien, Friedrich Bake, Matthias Ihme,** "Modal Analysis of Direct Core Noise in a Model Combustor," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

39. **Xin Xue, Chih-Jen Sung, Hai Wang,** "Effect of Distillate Fraction of Real Jet Fuel on Sooting Propensity – Part 2: Soot Formation in Nonpremixed Counterflow Flames," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

40. **John Palmore Jr., Olivier Desjardins,** "Simulations of Vaporizing Droplets in Turbulence," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

41. **Gerald Mairinger, Alessio Frassoldati, Alberto Cuoci, Ernst Pucher, Kalyanasundaram Seshadri,** "Autoignition of Jet Fuels and Surrogates in Nonpremixed Flows at Elevated Pressures," 10th US National Combustion Meeting, College Park, Maryland, April 23-26, 2017.

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- Y. Tang, M. Hassanaly, V. Raman, B. Sforzo, S. Wei and J. Seitzman, "Simulation of Gas Turbine Ignition Using Large Eddy Simulation Approach," GT2018-76216 Proceedings of the ASME/IGTI Turbo Expo 2018, June 11-14, 2018 Oslo Norway.
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Supplemental Material