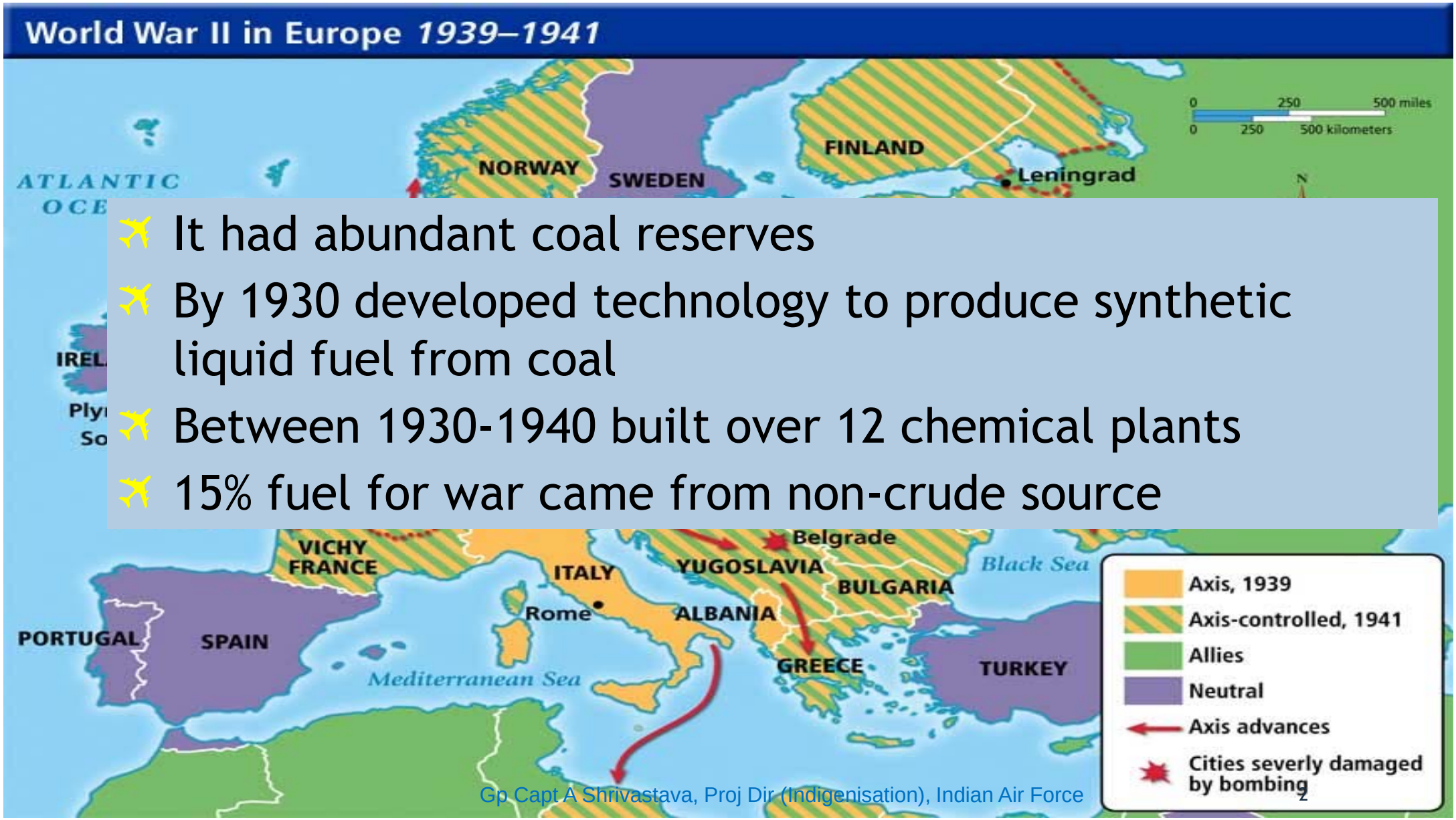
- All war waging machinery - dependent on gasoline and Diesel for Mil Ops
- Germany had virtually no petroleum deposits
- HOW DID GERMANY SUSTAIN WAR EFFORTS ?



- It had abundant coal reserves
- By 1930 developed technology to produce synthetic liquid fuel from coal
- Between 1930-1940 built over 12 chemical plants
- 15% fuel for war came from non-crude source

ENERGY SECURITY

IAF's TRYST WITH SYNTHETIC FUEL

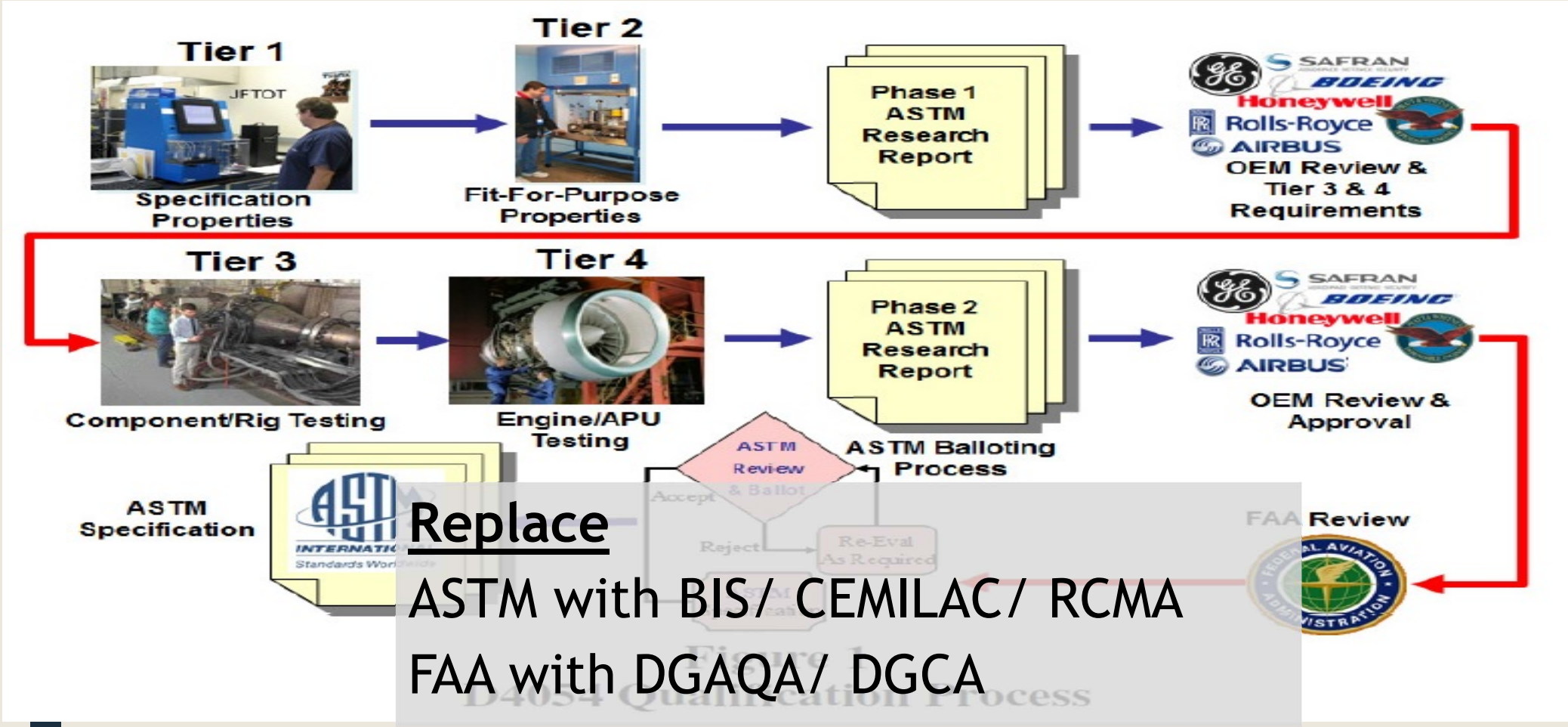
Why Bio-jet fuel for IAF ?

- Fossil fuel centric to Military operations
- Energy security- reduce import
- Enrich farmer- Fuel from waste
- Promote indigenisation- foster R &D
- Support domestic aviation sector - CORSIA

IAF's STRATEGIC APPROACH

- IAF has over 1800 aircraft
- Consumes < 800 M ltrs of ATF annually
- Offered use of military infrastructure to develop, test and certify the use of bio-jet fuel
- Like USAF – AFRL foster indigenisation
- Funded a development program with CSIR-IIP
- Developed the Indian Stand for Synthetic Fuel IS:17081 in-line with ASTM D7566
- **Designed a testing methodology like ASTM D4054 for evaluating & approving aviation jet fuels**

FAA RECOMMENDED TESTING PROCEDURE



Replace

ASTM with BIS/ CEMILAC/ RCMA

FAA with DGAQA/ DGCA

OEM with ASTE/ BRD

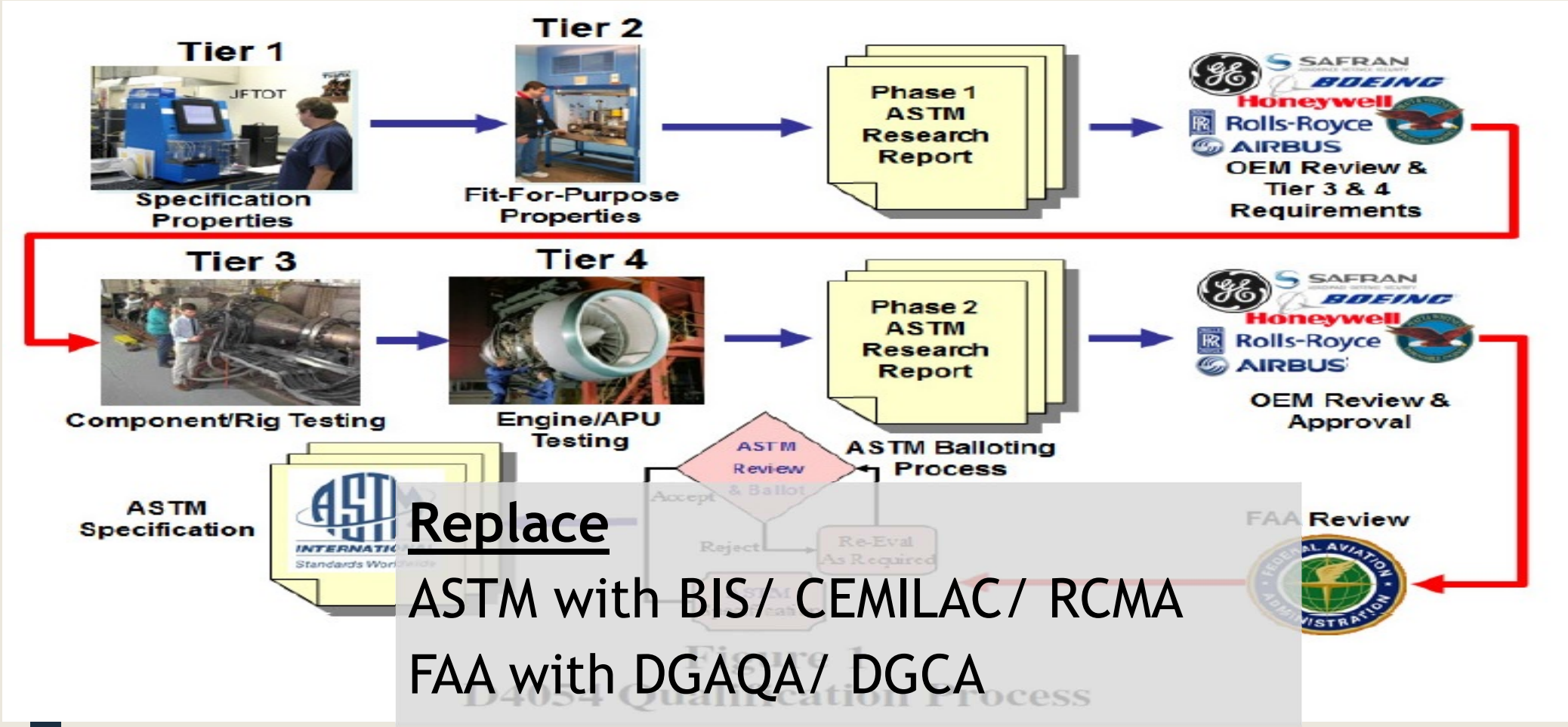
INDIAN STANDARD IS 17081

- Similar to ASTM D7566
- Describes 05 pathways (ASTM has 06)
- Different feedstock for each pathway
- Finished product of every pathway - identical
- Testing and certification for indigenous HEFA pathway completed
- Evaluation of ATJ-SPK pathway samples underway
- **Feedstock supply, technology support, distribution network and funding supported by the <u>National Biofuel policy 2018</u>**

NATIONAL POLICY ON BIOFUELS 2018

- Notified on 04 Jun 18
- Sets targets to Reduce Crude Imports, Enhance Farmers' Income, Generate Employment and Create Wealth from Waste
- Focus on increasing contribution of biofuels in India's energy basket & promoting use of domestic feedstock
- Includes 'Drop-in Jet Fuel'
- Proposes financial initiatives like VGF, subsidies and grants
- **Creates NBCC**

FAA RECOMMENDED TESTING PROCEDURE



Replace

ASTM with BIS/ CEMILAC/ RCMA

FAA with DGAQA/ DGCA

OEM with ASTE/ BRD

CSIR-IIP Biojet fuel Tested at RIL, Jamnagar							
Date of Sample receipt: 17th Sept 2019		Sample Provided by: Airforce HQ			Date of Testing: 18th & 19th Sept 2019		
Characteristics	Requirement	Test Method	UOM	Result (100% CSIR-IIP Biojet)	Result (50% CSIR-IIP Biojet + 50% Jet A1)	Result (10% CSIR-IIP Biojet + 90% Jet A1)	Result 100% Jet A1 (652-021 RIL ATF)
Appearance:							
a) Visual appearance	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature	Visual (see Annex D of IS 1571)	NA	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature
b) Saybolt Colour	To report	[P : 14]/ASTM D 156*/D 6045	Number	+30	+25	+21	+19
c) Particulate contamination, at point of manufacture	1.00 Max	ASTM D 5452*/IP 423	mg/litre	---	---	---	0.66
d) Particulate, at point of manufacture, cumulative channel particle counts,	Channel counts ISO Code	IP 564*, IP 565 or IP 577					
1) ≥ 4 µm(c)	To report	To report	Nos / (Count/ml)	76.5/13	-	-	4882.8/19
2) ≥6 µm(c)	To report	To report	Nos / (Count/ml)	38.1/12	-	-	731.3/17
3) ≥14 µm(c)	To report	To report	Nos / (Count/ml)	9.6/10	-	-	31.7/12
4) ≥21 µm(c)	To report	To report	Nos / (Count/ml)	4.3/9	-	-	5.5/10
5) ≥25 µm(c)	To report	To report	Nos / (Count/ml)	3.0/9	-	-	2.9/9
6) ≥30 µm(c)	To report	To report	Nos / (Count/ml)	1.8/8	-	-	1.5/8
Composition:							
a) Total acidity	0.015 Max	[P : 113]*/IP 354/ASTM D3242	mgKOH/gm	0.007	0.004	0.003	0.002
b) Aromatics conetent	25.0 Max (CIVIL), 22.0 Max (DEFENSE)	[P : 23]*/IP 156/ASTM D 1319	vol. %	7.1	12.3	16.6	17.7
Total Aromatics, v/v percent, Max	26.5 Max	IP 436/ASTM D 6379*	vol. %	7.8	---	---	---
c) Total sulfur	0.300 Max (CIVIL), 0.250 Max (DEFENSE)	[P : 34]/ISO 8754/ASTM D 4294*/ASTM D5453	% mass	0.0012	0.060	0.108	0.121
d) Sulfur mercaptan	0.0030 Max (CIVIL), 0.0020 Max (DEFENSE)	[P : 109]*/IP 342/ASTM D 3227	% mass	0.0004	0.0009	0.0013	0.0014
e) Doctor Test	Negative	[P : 19]*/IP 30/ASTM D 4952	NA	Negative	Negative	Negative	---
f) Refining components, at the point of manufacture							
1) Non Hydroprocessed Components	To report	Declaration	vol. %	---	---	---	79.3
2) Mildly Hydroprocessed Components	To report	Declaration	vol. %	---	---	---	20.7#
3) Severely Hydroprocessed Components	To report	Declaration	vol. %	---	---	---	Nil
4) Synthetic Components	To report	Declaration	vol. %	---	---	---	Nil
i) Name of the component	SPK-HEFA						
ii) Component, v/v percent, Max	Max 50% by v/v						

Characteristics	Requirement	Test Method	UOM	Result (100% CSIR-IIP Biojet)	Result (50% CSIR-IIP Biojet + 50% Jet A1)	Result (10% CSIR-IIP Biojet + 90% Jet A1)	Result 100% Jet A1 (652-021 RIL ATF)
iii) Volatility:		[P : 18]*/IP 123/ASTM D 86					
a) Distillation:							
1) Initial boiling point	To report		°C	162.0	158.0	156.0	156.0
2) 10 percent recovery	205.0 Max		°C	178.0	174.0	171.0	171.0
3) 50 percent recovery	To report		°C	205.0	197.0	191.0	191.0
4) 90 percent recovery	To report		°C	242.0	231.0	220.0	217.0
5) Final boiling point	300.0 Max		°C	256.0	251.0	241.0	235.0
6) Residue	1.5 Max		vol. %	1.2	1.1	1.0	1.0
7) Loss	1.5 Max		vol. %	0.5	0.5	0.5	0.6
b) Flash point (Abel CC)	38.0 Min	[P : 20]*/ISO 13736/IP 170	°C	48.0	44.5	43.5	43.5
c) Density at 15°C	775.0 to 840.0	[P : 16]*/IP 160/ASTM D 4052	Kg/m3	769.1	781.5	791.3	793.5
iv) Fluidity							
a) Freezing point	-47.0 Max	[P : 11]*/IP 16/ASTM D 2386/D7153	°C	-44.5	-53.5	-57.0	-58.0
b) Kinematic viscosity at minus 20°C	8.000 Max	[P : 25/Sec 1]*/IP 71/ASTM D 445	mm2/s	4.340	3.828	3.468	3.403
v) Combustion:							
a) Specific energy	42.80 Min	[P : 6]/ASTM D 3338*	MJ/kg	43.84	43.55	43.31	43.26
b) Smoke point OR	25.0 Min	[P : 31]/IP 598*/ASTM D 1322	mm	---	---	---	---
1) Smoke point and	18.0 Min	[P : 31]/IP 598*/ASTM D 1322	mm	39	30	25	24
2) Naphthalenes	3.00 Max	[P : 118]*/ASTM D 1840	vol. %	0.22	0.45	0.62	0.66
vi) Corrosion:							
a) Copper strip corrosion for 2 h at 100°C	Not worse than No. 1	[P : 15]*/IP 154/ASTM D 130	Rating	1a	1a	1a	1a
b) Silver strip corrosion12) classification, for 4 h at 50oC, Max	"0" at Refinery "1" at Delivery Point	IP 227/ 99	Rating	Zero	Zero	Zero	Zero
vii) Thermal Stability, JFTOT at Control Temperature of 260°C							
a) Filter pressure differential, mm Hg, Max	25 Max	[P : 97]/IP 323/ASTM D 3241*	mmHg	0	0	0	0
b) One of the following requirement to be met							
i) Tube rating, visual (VTR) or	Less than 3, No 'Peacock' (P) or 'Abnormal' (A)		NA	<1.No "Peacock" or "Abnormal" colour deposite	<1.No "Peacock" or "Abnormal" colour deposite	<1.No "Peacock" or "Abnormal" colour deposite	<1.No "Peacock" or "Abnormal" colour deposite
ii) ITR or ETR, average over area of 2.5 mm2, nm, Max	85			---	---	---	---

CSIR-IIP Biojet fuel Tested at RIL, Jamnagar: Detailed test for CSIR-IIP Biojet fuel			
Batch Requirements of 100% Synthesized Hydrocarbons SPK-HEFA			
Test Parameter	Spec	Test Method	Result (100% CSIR-IIP Biojet)
i) Composition:			
a) Acidity, total mg KOH/g, Max	0.015	[P : 113]/D3242/IP 354	0.007
ii) Volatility:			
a) Distillation-both of the following requirements shall be met:		[P : 18]/D86/IP 123/D7345	
(1) Physical Distillation temperature, °C	-	-	-
i) 10 percent recovered, temperature (T10) Max	205		178
ii) 50 percent recovered, temperature (T50)	report		205
iii) 90 percent recovered, temperature (T90)	report		242
iv) Final boiling point, temperature Max	300		256
v) T90-T10, °C Min	22		64
vi) Distillation residue, v/v percent Max	1.5		1.2
vii) Distillation loss, v/v percent Max	1.5		0.5
(2) Simulated Distillation temperature, °C		D2887	Tested above by ASTM D 86
i) 10 percent recovered, temperature (T10)	report		
ii) 50 percent recovered, temperature (T50)	report		
iii) 90 percent recovered, temperature (T90)	report		
iv) Final boiling point, temperature			
iii) Flash point, °C, Min	38	[P : 20]/ISO 13736/D3828/IP 170/IP 523	48.0
iv) Density at 15 °C, kg/m3	730 to 772	[P : 16]/D1298/IP 160/D4052/IP 365	769.1
v) Freezing point, °C, Max	-40	[P : 11]/D5972/IP 435/D7153/IP529/D7154/IP528/D2	-44.5
vi) Existent gum, mg/100 ml, Max	7	[P : 29]/D381/IP 540	<1.0
vii) FAME, ppm, Max	<5	[P : 585]/IP 590	ND (<4.5)
viii) Thermal Stability (2.5 h at control temperature)			
a) Temperature, °C, Min	325	[P : 97]/D324/IP 3237)	325
b) Filter pressure drop, mm Hg, Max	25		0
c) Tube rating: One of the following requirements shall be	< 3		
1) Tube rating, visual (VTR) or	Less Than 3, No peacock or abnormal color deposits		<1.No "Peacock" or "Abnormal" colour deposite
2) ITR or ETR, average over area of 2.5 mm2, nm, Max	85		---
ix) Additives			Test facility not available
Antioxidants, mg/l	17-24		
x) Hydrocarbon Composition:		D2425	
a) Cycloparaffins, m/m percent, Max	20		
b) Aromatics, m/m percent, Max	15		
c) Paraffins, m/m percent	report		
d) Carbon and Hydrogen, m/m percent Min	99.5	D5291	
xi) Non- Hydrocarbon Composition:			
a) Nitrogen, mg/kg, Max	2	D4629/IP 379	0.5
b) Water, mg/kg, Max	75	D6304/IP 438	<10
c) Sulfur, mg/kg, Max	50	~~D2622/D4294~~/D5453	12
d) Metals	0.1 per metal	UOP 389/D 7111 / ICP-OES	

FOUNDRY & FORGE DIVISION
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Email : dgmcmpl.fnf@hal-india

CENTRAL MATERIALS AND PROCESSES LABORATORY

TEST REPORT

Ref: F/CL/CO/ RC-1001

Date: 03.11.2018

Customer	:	CSIR, IIP-DEHRADUN
Customer Reference	:	IIP/Pur/2/18-19/466/SAF/CCD/PO:210, 20th September18
Customer code/Identification on sample/item	:	BIO-ATF
Date of receiving	:	28 .09.2018
Condition of sample	:	Liquid
Sales Order no.	:	SO/LT/ 1535, dated 24.10.2018
Test standard / specification	:	ISO 2781, ISO 48, ISO 37 and BS 903 A16, A19
Sampling by	:	Customer
Test Results	:	

Continued on page 2

Registered Office: 15/1, Cubbon Road, Bangalore – 560 001, India. Website: www.hal-india.com
CIN: L35301KA1963GO1001622

FOUNDRY & FORGE DIVISION
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TRAL MATERIALS AND PROCESSES LABORATORY

TEST REPORT

001

Date: 03.11.2018

Tests	NITRILE RUBBER SHEET/21A7
n	
	64-65
tion agnification &	
dition A	Sample parts are smooth, uniform and free from defects like cuts, cracks etc.
dition B	--do---
dition C	Cuts and cracks noticed on the sample after immersion *
dition D	Sample parts are smooth, uniform and free from defects like cuts, cracks etc.
dition E	--do---
thro 180°	
ition A	No cuts, cracks or any other defects noticed
ition B	--do--
ition C	Cuts and cracks noticed on the sample after immersion *
ition D	No cuts, cracks or any other defects noticed
ition E	--do--
Volume (%)	
ition B	+ 1.6
ition C	+ 4.0
ition D	+ 2.9
ition E	+ 3.7

ffice: 15/1, Cubbon Road, Bangalore – 560 001, India. Website: www.hal-india.com
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CENTRAL MATERIALS AND PROCESSES LABORATORY

TEST REPORT

F/CL/CO/ RC-1001

Date: 03.11.2018

Tests	NITRILE RUBBER SHEET Results Obtained
Tensile Strength (Kgf/cm^2) Condition A	185
Variation in Tensile Strength (%) Condition B Condition C Condition D Condition E	 -8.9 -81.2 -10.5 -79.4
Elongation (%) Condition A	397.3
Variation in Elongation (%) Condition B Condition C Condition D Condition E	 -7.0 -97.5 -13.0 -92.5
Compression Set Test (%) Condition B Condition C Condition D Condition E	 9.7 22.7 6.15 48.4
Variation in Hardness (points) Condition B Condition C Condition D Condition E	 -2 -20 -1 -13

E:
lition A : As received
lition B : After immersion in 100% Bio Fuel at Room Temp for 48 hrs.
lition C : After immersion in 100% Bio Fuel at 150 ^{0}C for 48 hrs.
lition D : After immersion in 50:50 (Bio Fuel:ATF) at Room Temp for 48 hrs.
lition E : After immersion in 50:50 (Bio Fuel:ATF) at 150 ^{0}C for 48 hrs.

CLUSION: Results Reported.

ANIL KUMAR D REVANKAR
DEPUTY MANAGER (LAB)

Registered Office: 15/1, Cubbon Road, Bangalore – 560 001, India. Website: www.hal-india.com
CIN: L35301KA1963GO1001622

SUMMARY OF TESTING

TEST REPORT OF ENGINE, Sl. No H21145 D059 **Type of testing «____» _____ 20** | Sheet No. 12 | Test bench No. 9

Time hour	Time min	Parameters of starting	Engine power rating	n, rpm, %	FCU α_{th}	Voltage Main	Voltage auxiliary	Oil pressure, kg/cm²: P_{oil} in	P_{oil} out	Engine oil, P_{oil}	P_{oil} CP	P_{oil} FP	P_{oil} PL	P_{oil} sc +P_b	Oil temperature, °C: inlet	outlet	Fuel pressure, kg/cm²: Inlet fuel pressure, P_f	Fuel booster pump outlet pressure, P_f	Main fuel nozzles inlet fuel pressure, P_f	Flow duct: P_2, kgf/cm²	t1, °C	P_0, mm Hg	$P_{oil\ inj}$, kg/cm²	Measured fuel flow rate, sec	Air pressure: Reduction gear nose, kg/cm²	Front casing, mm Hg	T oil in $V_{oil\ tank}$	Turbine cooling: P_w, mm H_2O	Δh, mm H_2O	Accessories units: Starter-generator V	I	cooling	Generator V	I	cooling	Hydraulic pump P_{in}	P_{out}
								P_f by 13 to 16%	P_{oil} in 15 to 25 sec		RH starter-generator V	RH starter-generator I	LH starter-generator V	LH starter-generator I	Starter-generator disengagement, rpm		Starter-generator operating time	t_0, °C, over temperature	ABV closing rpm: g	ABV closing rpm: 5	Time of acceleration to idle rating, sec	$t°_{oil\ in}$ at starting	Runout time: Y	Runout time: From 85%												
Date		Running HRS [HH:MM]		Fuel Consumed [In Ltr]				SM 4.5 Consumed [In Ltr]		TH 321 Consumed [In Ltr]																											
14/05/19		00:15		90				–		–																											
16/05/19		02:20		1700				–		–																											
TOTAL		02:35		1790				1.6 Ltr		–																											

No. of c/c :	06
No. of f/c :	03
No. of Start:	07
Total :	16

Idle to cruise	HRS	: 02:30
NE	HRS	: 00:03
T/off	HRS	: 00:02
Total Running	HRS	: 02:35

Fuel (BIOFUEL + ATF) consumed:	1790 Ltr
SM 4.5 Consumed:	1.6 Ltr
TH 321 Consumed:	NIL

ADJUSTMENT

(P Kumar)	(T K Roy)	(D P Singh)
Cpl	MNO	JWO
Technician	Supervisor	QAE

READJUSTMENT

(P Kumar)	(T K Roy)	(D P Singh)
Cpl	MNO	JWO
Technician	Supervisor	QAE

(Vivek Kumar) Cpl Technician | (T K Roy) MNO Supervisor | (D P Singh) JWO QAE

फोन/Phone : 2512301

सभी पत्रादि मुख्य कार्यपालक (उड़नयोग्यता) को सम्बोधित किया जाए और न किसी अन्य अधिकारी के उपनाम से
All correspondence should be addressed to the Chief Executive (Airworthiness) and not to any officer by name.

CEMILAC

भारत सरकार
Government of India
रक्षा मंत्रालय
Ministry of Defence
रक्षा अनुसंधान तथा विकास संगठन
Defence Res. & Dev. Organisation
सेना उड़नयोग्यता और प्रमाणीकरण केन्द्र
Centre for Military Airworthiness & Certification (CEMILAC)
मारत्तहल्ली कालोनी पोस्ट
Marathahalli Colony (Post)
बेंगलूरु - 560 037
Bengaluru - 560 037

24 May 2019

CEMILAC/2502/GD(P)/Fuel

To

AWSC
Office of CAS
Room No 590 (C /11)
Air HQ, Rafi Marg
New Delhi - 110106

CLEARANCE FOR USE OF DROP IN ADMIXTURE BIO-ATF WITH TYPE APPROVED CONVENTIONAL ATF ON AN-32 AIRCRAFT

Introduction :

Bio-ATF for defence aviation application is developed and produced by IIP-CSIR had undergone Aero Engine test bed trials on Al 20D engine, flight trial on AN-32 Aircraft as per Development Test schedule drawn by RCMA (F&F-FOL) in coordination with IIP-CSIR,3 BRD and ASTE. 3BRD and ASTE reported that the test bench, EGR data of aero engine, aircraft flight trial performance were in confirmation with the aircraft OEM flight manual and was found satisfactory within the operational envelope of AN -32 aircraft.

2. Flight operational Clearance :

Limited Flight Clearance is hereby accorded to Aviation Bio-jet(Drop-In) ATF (containing blend of up to 10% by volume Bio ATF with Type Approved conventional ATF) for use on AN32 aircraft with in the range

Phone : 080-25230680, 25121000, 25121001, Fax : 080-25230856 E-mail : chief@cemilac.drdo.in



STAGES IN TESTING AND CERTIFICATION OF BIO-JET

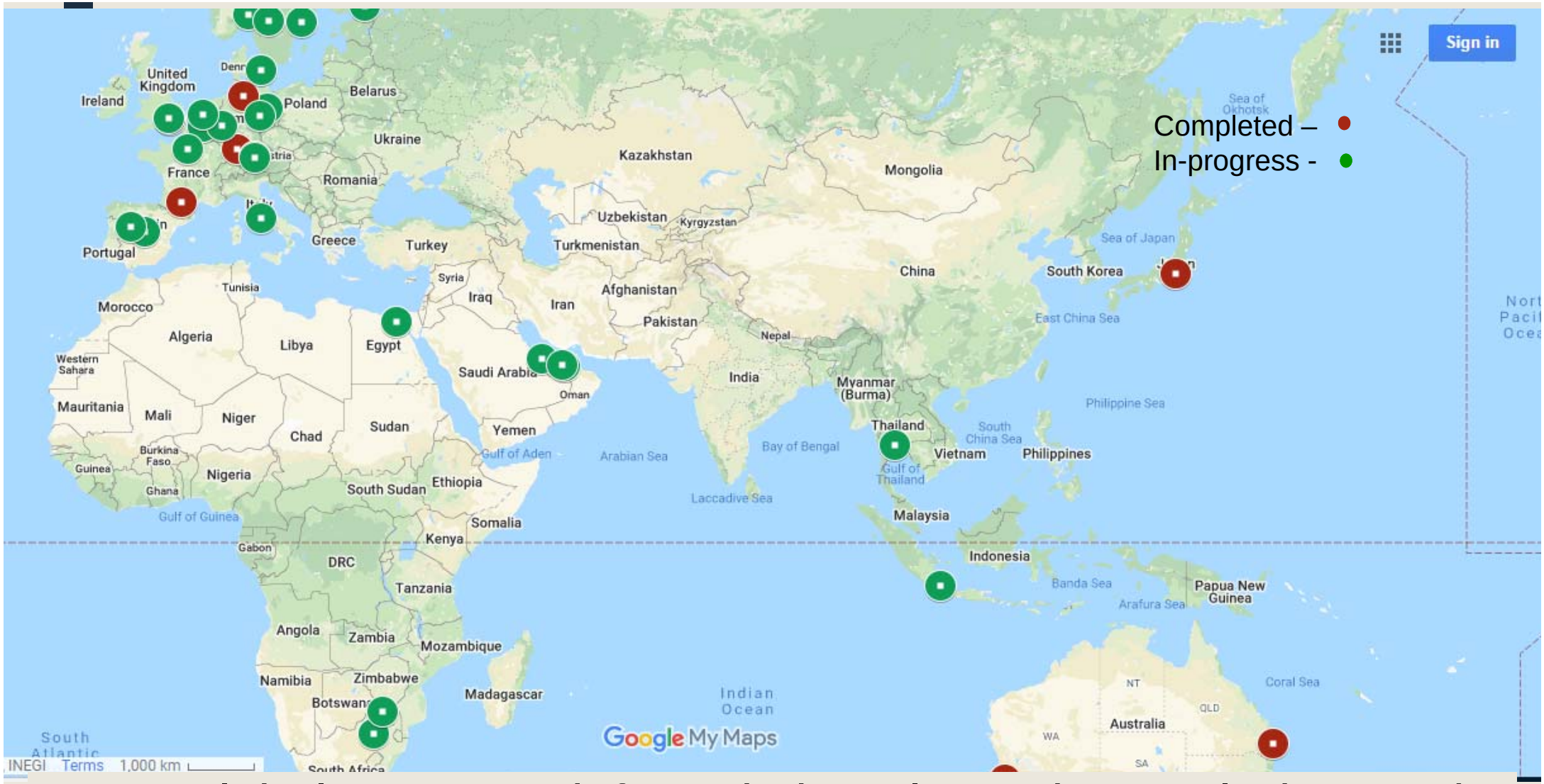





Gp Capt A Shrivastava, Proj Dir (Indigenisation), Indian Air Force

WAY FORWARD

- Test and certify bio-jet produced using innovative technologies partnered with R&D and industries
- Foster growth and early commercialization
- IAF ready to nurture technologies for Indian aviation fuel industry
- Enable CORSIA compliant Indian aviation sector
- Create SAF supply base in India – Distributed Model
- **Place India on ICAO's GFAAF map**



ICAO Global Framework for Aviation Alternative Fuels (GFAAF)

RECOMMENDATIONS

- Bio-jet can promote economic growth across various sectors
- India blessed with abundant sunshine, vide variety of vegetation and ample farm waste
- Oil refineries need to develop/ co-produce bio-jet fuel to meet climate change challenges (GHG)
- Jet fuel sales may recede on International routes
- **Need to reduce <u>technology</u> gestation period**
- **IAF ready to manage this change**

FLIGHTS WITH BIO-JET FUEL

AN-32 formation over Rajpath
26 Jan 19

AN-32 Taking-Off from Leh on
31 Jan 20

THANK YOU