



Direct Sugar to Hydrocarbon (DSHC) From Research to Commercialization

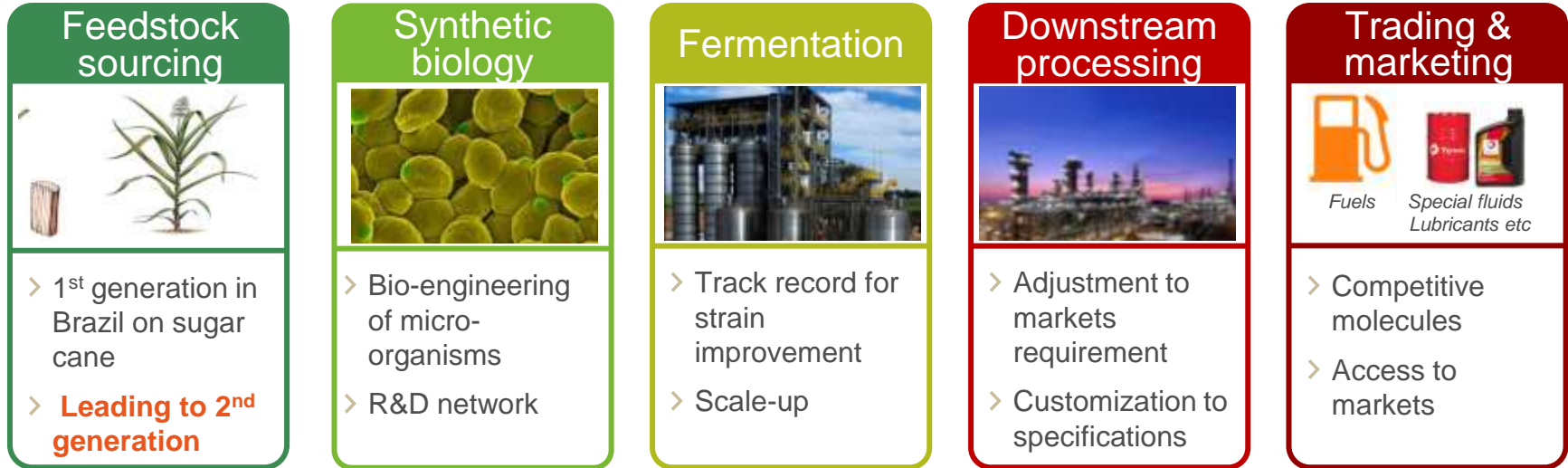
The platform molecule farnesane [2,6,10-] trimethyl-dodecane

Dr. Ralf Stöckel, TOTAL New Energies

FIRST ANNUAL WORKSHOP OF ISAFF
ROME, 4 NOVEMBER 2014

TOTAL Amyris DSHC pathway

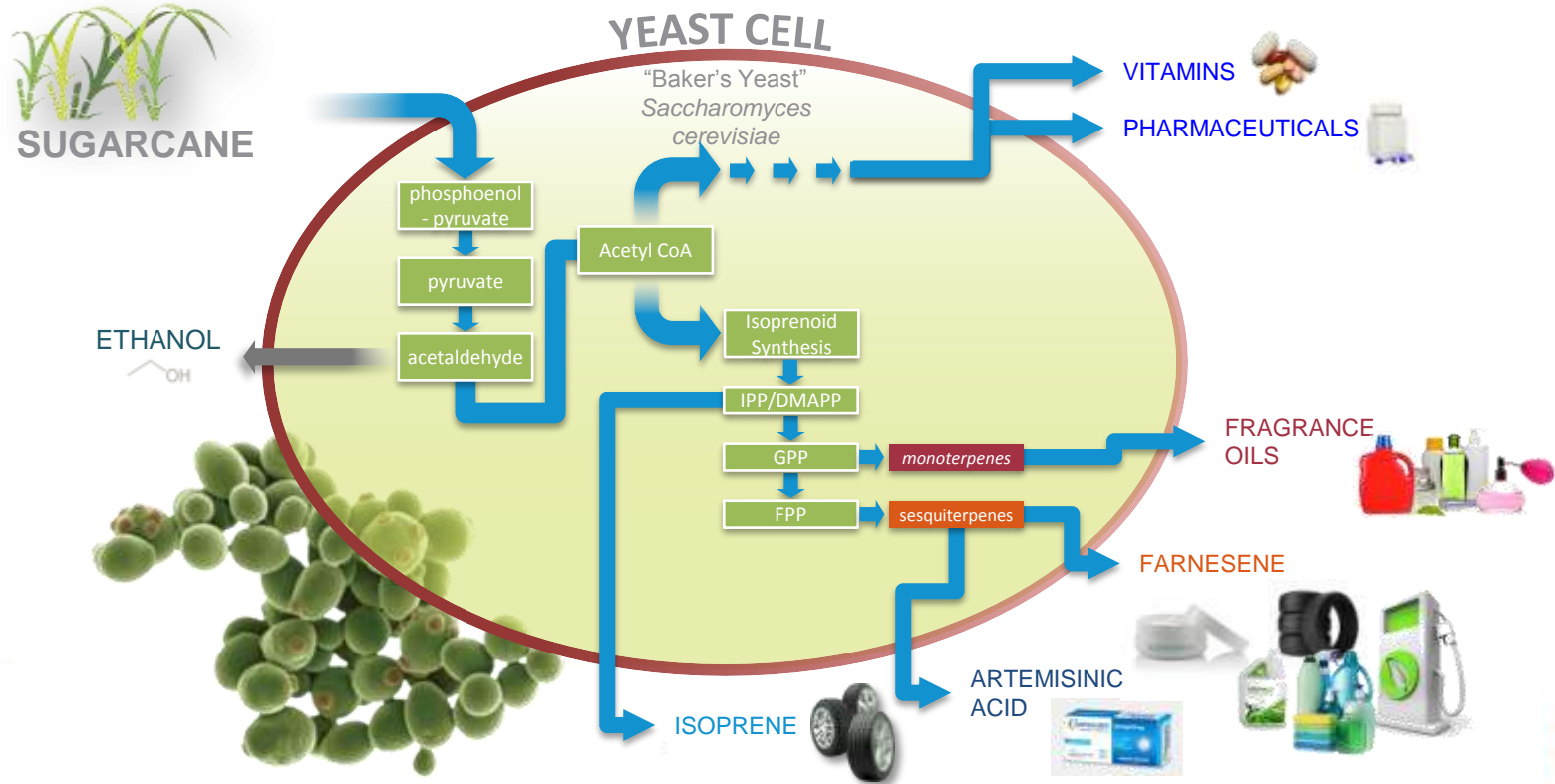
Develop the **whole value chain** integrated from biomass to finished products



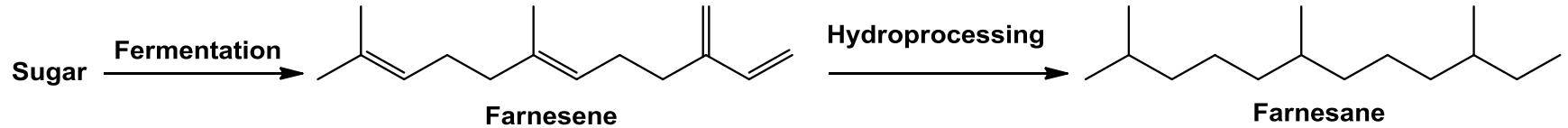
The development of a renewable jet fuel technology was the first joint program



Choosing the right metabolic pathway



An innovative technology based on standard industrial operations



1) Fermentation



- **Microbe-catalyzed conversion** of sugar: key is the development of a farnesene producing yeast via innovative biotechnology for which Amyris is a leader
- Amyris industrial farnesene plant, with a capacity of **up to 50 million liters per year** at target efficiency, was started-up in 2012 in Brotas, São Paulo State, Brazil, where the largest availability of sustainable sugar can be found



Certification process: initial view (1/2)

ASTM approval is a mandatory, **consensual**, sequential and heavy process to demonstrate the **harmlessness of the blended component**

1 year, \$0.5m, 0.5 m³

1 year, \$1.5m, ~55 m³

1 year, \$1-5m, 30 m³

1 year, \$1-5m, 2,000 m³



Specification
Properties

Fit-For-Purpose
Properties

Component/
Rig Testing

Engine/
APU Testing

Endurance
Testing



Demo-flights before certification



2012: Brazil (conference Rio+20)

- Airplane: Embraer 190
- Company: Azul



2013: France (salon du Bourget)

- Airplane: Airbus A321
- Company: Air France

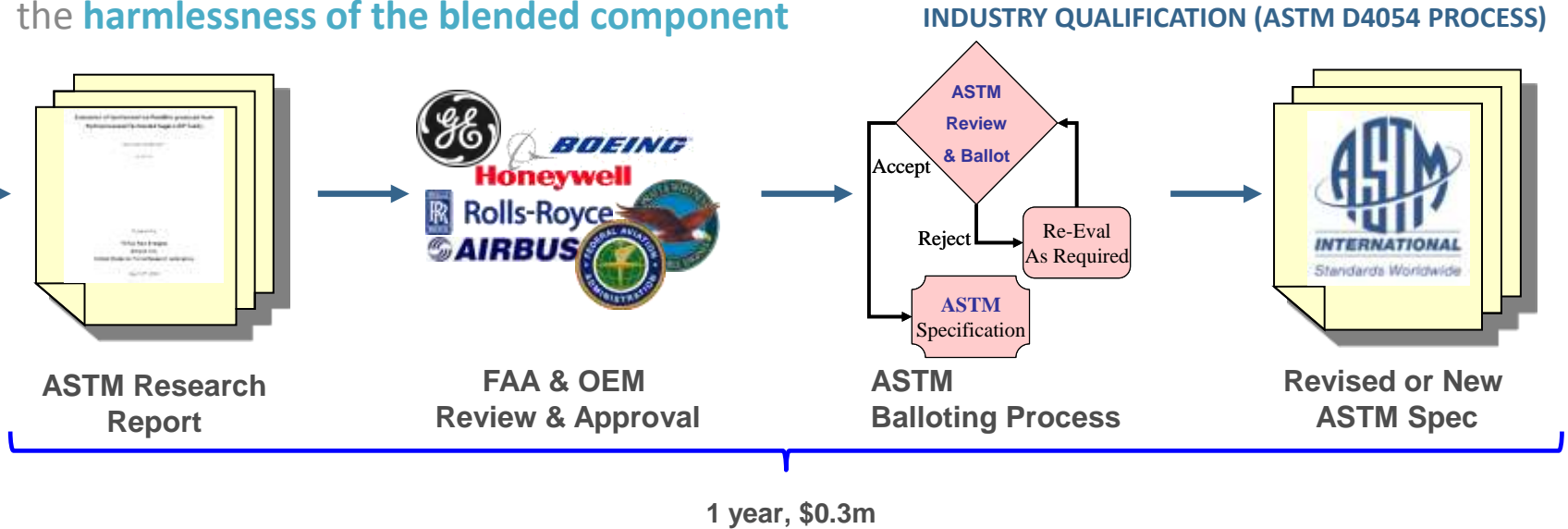


2014: United Arab Emirates (flight path to sustainability)

- Airplane: Boeing 777
- Company: Etihad

Certification process: initial view (2/2)

ASTM approval is a mandatory, **consensual**, sequential and heavy process to demonstrate the **harmlessness of the blended component**



Benchmark: i) 4-5 years; ii) 100 to 2,000 m³; iii) 5 M\$-15 M\$

1st commercial flights



31/07/2014

- Airplane: Boeing 737
- Company: GOL
- Flight: G3-7725, Orlando -> São Paulo



15/09/2014: Allemagne

- Airplane: Airbus A321
- Company: Lufthansa
- Flight: LH190, Francfort -> Berlin



17/09/2014: France (AF Lab'line of the future)

- Airplane: Airbus A321
- Company: AIRFRANCE
- Flight: AF 6313, Toulouse -> Paris

Lessons learned – main findings

feedstock

- Today: Mon- & Di-saccharides the most disposable bio based feedstock
- Tomorrow: cellulose based arbitrabel feedstocks

transformation

- Biochemical pathway
- engineered microorganism
- Feedstock agnostic

Certification

- Done up to 10% blends
- Higher blends technically possible

Commercialisation

- First Pioneers found (GOL, Lufthansa, Airfrance)
- Locking for partnership with more frontrunners

Merci beaucoup pour votre attention!

Thank you for your attention!

Muito obrigado pela sua atenção!

Vielen Dank für Ihre Aufmerksamkeit!

La ringrazio per il Sua attenzione!

