Business Aviation - Sustainability in a World of Change

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Aviation Sustainability: Policy Context

• International Business Aviation Council
• International Civil Aviation Organization
• Politics of Aviation Noise and Climate Change
• Industry Commitment
• ICAO Action and Next Steps
International Business Aviation Council

• A non-profit, international trade association representing the interests of business aviation at the global level.

• A federation of 14 national & regional business aviation associations.

• Directed by the Governing Board, with each association having one member on the Board.
IBAC Global Membership
IBAC Mission

• Advocate at ICAO, in global and regional venues.
  – Permanent observer status at ICAO.
• Raise awareness of business aviation and its benefits around the world.
• Support members.
• Promote best safety practices.
International Civil Aviation Organization

• Specialized agency of the United Nations, established in 1944, with 191 member states.

• Sets global standards & recommended practices.
  – Safety
  – Air navigation
  – Security
  – Environment
  – Facilitation
Politics of Noise & Climate Change

• Noise: Constant pressure for quieter aircraft
  – Phase-out of Chapter 2 aircraft
  – EU Hushkits Regulation, operational restrictions

• Climate Change: Pressure for all industries to contribute
  – Kyoto Protocol → ICAO
  – EU Emissions Trading Scheme
Industry Commitment

• Industry has an excellent environmental record
  – Noise: Since 1975, 95% reduction in number of people exposed to significant noise in the U.S.
  – Emissions: 40% fuel efficiency improvement in last 40 years
  – Aviation carbon emissions are ≈ 2% of worldwide carbon emissions.
  – Bizav ≈ 0.04% of global man-made carbon emissions

• Industry is incentivized by the market.
Industry Commitment – Noise

• Active contributor to work on global standards at ICAO (Committee on Aviation Environmental Protection – CAEP).
• Participation was critical to establishing a new noise standard from 2017 and 2020.
• Work with local partners at airports and in communities.
Industry Commitment – Climate Change

- Fuel-efficiency improvement of 2 percent per year until 2020;
- Carbon-neutral growth from 2020; and
- 50 percent reduction of carbon emissions by 2050 relative to 2005 levels.
Climate Change Commitment – Strategy

**Invest in new TECHNOLOGY**
(including sustainable aviation biofuels)

**Fly using more efficient OPERATIONS**

**Build and use efficient INFRASTRUCTURE**

**Use effective, global, MARKET-BASED MEASURES**
Climate Change Commitment – Strategy

- Market Based Measures
- Technology
- Operations and Infrastructure
- Alternative Fuels
ICAO Action

• The industry commitment was a breakthrough 3 years ago & continues to be basis for global action.
• The 38th ICAO Assembly called on all governments to accelerate technology development, infrastructure modernization, and more efficient operational procedures....most promise to achieve goals.
• Endorsed work on CO₂ standard for aircraft and called for completion of that work by 2016.
ICAO Assembly MBMs Outcome

• For current and new MBMs until 2020 – mutual consent

• Beyond 2020: The ICAO Council and governments to work on developing a global MBM for consideration and decision at the next Assembly in 2016. If adopted, the scheme would be implemented from 2020.

• Interests of business aviation explicitly taken into account: administrative simplicity and consideration of exemptions for small operators.
Conclusion

• Background on ICAO and IBAC
• Politics of Noise and Climate Change
• Industry Commitment – the Four Pillars
• ICAO Action – Key aspects include work on
  – New noise standard
  – CO₂ standard
  – Acceleration of development and deployment of sustainable alternative fuels
  – Reasonable approach to MBMs
Noise Standards in a Changing World

Dan Brown
Development of Aircraft Noise Standards

United Nations

International Civil Aviation Organization (ICAO)

Committee on Aviation Environmental Protection (CAEP)

Body of several member states & observer organizations including IBAC and NBAA

Commissions environmental cost/benefit studies of possible new regulations

Agrees on new regulations like ICAO Annex 16 Vol 1 – Noise Ch14

National Regulations Used for Aircraft Certification

USA (FAA): CFR Part 36

EU (EASA): ICAO Annex 16 Vol 1

CAEP Principle - New Environmental Regulations Must:
1) Be Environmentally Beneficial
2) Be Technically Feasible
3) Be Economically Reasonable
4) Consider Interdependencies
### ICAO Annex 16 Noise – Jet & Large Props

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<th>Aircraft</th>
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<td>Until 1977</td>
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<td>Subsonic Jet</td>
<td>From 1977 to 2005</td>
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<td>Propeller-Driven &gt; 8.6 ktonne</td>
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<td>Propeller-Driven &gt; 8.6 ktonne</td>
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<td>5</td>
<td>Propeller-Driven &gt; 8.6 ktonne</td>
<td>From 1977 to 1985</td>
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<tr>
<td>12</td>
<td>Supersonic</td>
<td>(studies underway)</td>
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<td>14</td>
<td>Subsonic Jet &lt; 55 ktonne</td>
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<td>Propeller-Driven 8.6 to 55 ktonne</td>
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3 Reference Points for Flyover Noise Cert

Flyover reference noise measurement point:
- The point on the extended centre line of the runway and at a distance of 6500 m from the start of roll.

Lateral full-power reference noise measurement point (since March 2002 for subsonic jet aeroplanes only):
- The point on a line parallel to and 450 m from the runway centre line, where the noise level is a maximum during take-off.

Approach reference noise measurement point:
- The point on the ground, on the extended centre line of the runway 2000 m from the threshold. On level ground this corresponds to a position 120 m vertically below the 3° descent path originating from a point 300 m beyond the threshold.
Allowable Noise Levels Scale with Aircraft Weight

Effective Perceived Noise Level (EPNdB) vs. Aircraft Maximum Takeoff Mass (1000 kg)

- 
  - Approach
  - Lateral
  - Flyover

Cumulative = Approach + Lateral + Flyover

Chap 3 Limits
Chap 4 = Ch3 - 10 cum

- Certification Limits
- Approach Margin
- Lateral Margin
- Flyover Margin

Measured Levels at Each Condition

Aircraft Certification MTOM
Analyses Used to Select Ch 14 Levels

- Developed a range of stringency options of between 3 and 11 dB cumulative margin relative to Chapter 4 with new slope at low mass
- No phase out of aircraft considered
- Did not preclude low carbon technology such as the open rotor
- Projected fleet out to 2036 using aeroplanes from Growth & Replacement Database
  - Studied equal and market-driven market shares by ICAO seat class
  - Technology response applied to aeroplanes that do not meet stringency option
- Assessed noise impact based on population highly annoyed by ICAO region for each scenario
  - Airport noise modeling tools by US FAA, UK CAA, & Eurocontrol
  - Mostly large airports
  - Impact dominated by scheduled airline service
- Costs determined base on operation of entire fleet
Results & Interpretation of Ch 14 Impact and Cost-Effectiveness Analyses

• Higher stringencies gave lower populations exposed to high noise levels
• Ch4 – 5 dB most cost effective
• Several states in favor of -5 dB and several others along with NGOs in favor of -9 to -11 dB
• Two states concerned about ability of regional aircraft to meet higher stringency due to slower technology insertion
• Compromise became Ch4 – 7 dB with staggered implementation dates
Ch 14 Relative to Certified Levels

- **Cumulative Noise Level (EPNdB)**
- **Maximum Takeoff Mass, 1000kg**
- **Ch4 = Ch3 - 10dB, 2 Engines**
- **Ch4 = Ch3 - 10dB, 3 Engines**
- **Ch14 = Ch4 - 7dB, 2 Engines**
- **Ch14 = Ch4 - 7dB, 3 Engines**

- **Bombardier - Jets**
- **Bombardier - Learjet**
- **Cessna**
- **Dassault - 2 Engine**
- **Dassault - 3 Engine**
- **Eclipse**
- **Embraer**
- **Gulfstream**
- **Hawker-Beechcraft**
- **737 family**
- **737MAX**
- **767**
- **787**
- **777**
- **747**
- **A320 family**
- **A320NEO**
- **A330**
- **A350**
- **A380**

- **7dB Lower at All Masses**
- **Revised Curve for Low Masses**

Legend:
- Orange line: Ch4 = Ch3 - 10dB, 2 Engines
- Dotted orange line: Ch4 = Ch3 - 10dB, 3 Engines
- Green line: Ch14 = Ch4 - 7dB, 2 Engines
- Dotted green line: Ch14 = Ch4 - 7dB, 3 Engines

Graph details:
- **After 2020**
- **After 2020 (55k)**
- **After 2017**

**Maximum Takeoff Mass, 1000kg**
- **1**
- **10**
- **100**
- **1000**
Impact of Ch 14 Stringency

• Nearly all in-production business aircraft are quieter than Ch 14 levels
  – Aircraft certified prior to 2017/2020 not required by authorities to comply
  – OEMs may recertify aircraft to Ch 14 standard

• Manufacturers of non-compliant aircraft may offer noise reduction upgrades if market demands it

• Project aircraft planned for certification in the next few years will likely comply

• CAEP encouraged states not to use new limits as a basis for operational restrictions
Topics

• A new aircraft certification standard is coming
  – $CO_2$ Standard

• Alternative Fuels
  – Can we use renewable fuels to reduce $CO_2$ emissions?
What is Business Aviation’s Contribution to Global CO₂?
Aviation’s Part of Global CO₂ Emissions

Business Aviation is reported to be approximately 2% of all Aviation’s CO₂ emissions.... So 2% of 2% ..or 0.04% of the Global CO₂ Emissions

Source: Intergovernmental Panel on Climate Change (IPCC)
Climate Change

• According to the 2013 Intergovernmental Panel on Climate Change (IPCC) Report, continued emissions of Greenhouse Gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

• IPPC Report indicates the goal is to keep the earth’s temperature from rising more than $2^0$ C (about $3.6^0$ F)

• Regulations related to Greenhouse Gases are already impacting many industries, not just aviation
Business Aviation Can Be Part of the Solution to Reduce CO$_2$ Emissions.... But How?
Reducing CO₂ Emissions in Aviation

• Improve the way you operate your aircraft
• Improve the air traffic management system
• Improve the fuel efficiency of aircraft
• Market Based Measures that benefit the environment

• Create a CO₂ standard to ensure less fuel efficient aircraft are discouraged and more fuel efficient aircraft will be an important part of the future
• Operate on a renewable fuel that reduces net CO₂
What Environmental Aspects of Aircraft are Regulated Today?
Current Emissions Requirements (Engine)

- Engine Certification Required
  - Smoke
  - Unburned hydrocarbons (UHC)
  - Carbon Monoxide (CO)
  - Oxides of Nitrogen (NOx)
- NOx is the only gaseous emissions requirement that has continued to be revised with reduced limits over time
- NOx is linked to Air Quality
Current Certification Requirements – A/C Level

• Aircraft are currently required to meet noise certification requirements
A New Aircraft Certification Standard is Coming!
Certification Requirements - Airplane Level

- A new aircraft level standard is in work that will be called a \textit{CO}_2 \textit{Standard}
  - Intended to make aircraft more fuel efficient
  - In the 4\textsuperscript{th} year of a 6 year development process
  - Being developed through the International Civil Aviation Organization (ICAO)
  - Goal is to finish by February 2016 (CAEP10)
  - Applicability will likely be \textit{2020 or 2023 for new types}
The New CO₂ Standard (1 of 2)

- Pass/Fail Certification Standard
- Will apply to new type designs
- May have in-production applicability (this would be new!)
- Applies to subsonic jet powered aircraft above 12,566 lbs MTOW
- Applies to propeller-driven aircraft above 19,000 lbs MTOW
- Each aircraft will get a “score” based on an agreed to set of procedures which will be regulated by the authorities
The New CO2 Standard (2 of 2)

- From the US, both the FAA and EPA are involved in the process
- Aviation representatives, including Business Aviation representatives (NBAA and OEM’s) are involved in the process
- Once approved, the Standard will need to be incorporated into national regulations (like the FAA’s Code of Federal Regulations)
- Fuel efficiency of aircraft will be regulated by the FAA in the US and by other civil aviation authorities in other countries
What other ways can Business Aviation Reduce CO$_2$ Emission?
By Using the Appropriate Alternative Fuels
Some Background First!

- Fossil fuels are made from the remains of ancient plants and animals, buried deep inside the earth for millions of years. Over a long, long time, heat and pressure has turned these remains into the fossil fuels that we call coal, oil and natural gas.
Alternative Fuels

- **Alternative fuels**, known as non-conventional or advanced fuels, are any material or substances that can be used as fuels, other than conventional fuels.
- **Examples are:**
  - Biofuel
  - Coal-to-liquid
  - Gas-to-liquid
  - Fuels made from Municipal Solid Waste
  - Fuels made from Animal Waste

**Renewable Diesel (R100)**
Are Alternative Fuels Used Today in Ground Transportation?
Ground Transportation Already Uses Alternative Fuels

- Gasoline may have Ethanol
  - E10 - Up to 10% ethanol
  - E85 - Up to 85% ethanol
- Made mostly from Corn in the US
- Sugar cane is a common feedstock in Brazil

Remember those days?
Ground Transportation already Used

Alternative Fuels

• Ultra Low Sulfur Diesel (ULSF)
  – Must meet the 15 ppm of sulfur content requirement (S15)
  – Reduces GHG
  – May contain up to 5% biomass based diesel
  – Available now in the US
  – One way to make ULSD is to mix a renewable diesel with petroleum based diesel
What is Motivating Suppliers to Use Renewable Fuels in Ground Transportation?
US Renewable Goals/Activities

- US Renewable Fuels Standard sets a goal of 36 billion gallons of renewable fuel to be blended into transportation by 2022, this is up from 9 billion in 2008
  - Obliges suppliers
  - Obligations can be met by producing only ground transportation fuels... this complicates the process to move renewable fuels into aviation

- USDA actively involved in developing Regional Road Map
Feedstock Assumption Summary

EPA expects the following feedstocks and the associated number of gallons by 2022:\(^1\):

- Switchgrass (perennial grass): \(7.9 \text{ bg}\)
- Soy biodiesel and corn oil: \(1.34 \text{ bg}\)
- Crop residues (corn stover, includes bagasse): \(5.5 \text{ bg}\)
- Woody biomass (forestry residue):
  (data does not include short-term woody crops) \(0.1 \text{ bg}\)
- Corn ethanol: \(15.0 \text{ bg}\)
- Other (municipal solid waste (MSW)): \(2.6 \text{ bg}\)
- Animal fats and yellow grease: \(0.38 \text{ bg}\)
- Algae: \(0.1 \text{ bg}\)
- Imports: \(2.2 \text{ bg}\)

Source: USDA Biofuels Strategic Production Report
Are Alternative Fuels Used Today in Aviation?
Alternative Fuels – Daily Operation

- Johannesburg's OR Tambo International Airport using Coal-To-Liquid (CTL) from SASOL in commercial airlines
- Providing CTL fuel for several years
- CTL Fuels do not have a net-CO$_2$ benefit
Alternative Fuels – Daily Operation

• Lufthansa was first airline to use biofuel on revenue flights
  – 6 month trial period ending in January of 2012
  – 50-50 blend of Jet A and biofuel (HEFA) on domestic routes during trial period
  – Trial was partly funded by German government
    • Study of long-term effects of biofuel use in commercial service
  – Only one engine used this fuel
  – Biofuel is produced by Neste Oil
  – Objective was to gather data on biofuel pollutants in comparison with conventional kerosene over a longer period of time
  – Estimated 1,471 metric tons of CO$_2$ saved
Alternative Fuels – Daily Operation

• KLM - 1 flight per week from NY to Amsterdam
  - Supplied by SkyNRG - approximately 15% - 25% blend
  - Partnerships includes: Schiphol Group, Delta Air Lines, the Port Authority of New York and New Jersey and KLM’s partners in the Corporate BioFuel Program

• British Airways agreed to purchase $500 million worth of sustainable jet fuel as part of its GreenSky London Initiative
  - Partnership with Solena Group
  - Feedstock will be municipal solid waste
  - Initial supply would be 2% of the total fuel consumption of British Airways.
United Airlines Partners with AltAir Fuels – 2014 Production Start

• “...cost-competitive, commercial-scale, sustainable aviation biofuel”
• 5 million usg/yr for 3 years targeted for LAX
• AltAir to produce HEFA-SPK Jet Fuel from plant and animal triglycerides at 30M usg/yr renewables refinery
• UOP instrumental in working for “bolt-on” refinery solution
How are Alternative Fuels Approved for Aircraft?
Industry Qualification (ASTM D4054 Process)

- Specification Properties
- Fit-For-Purpose Properties
- Component / Rig Testing
- Engine / APU Testing

2 Approved

Revised or New ASTM Spec

ASTM Balloting Process

Accept

ASTM Review & Ballot

Reject

Re-Eval As Required

ASTM Specification

FAA & OEM Review & Approval

ASTM Research Report

4 More Submitted

Reference: Mark Rumizen January 25, 2010
“Drop-In” Objective Achieved

Production

D7566
Semi-Synthetic Fuel

Tighter Control of Fuel Properties

Distribution

D1655
Conventional Jet Fuel

Separate Tracking NOT Required

Operations

D1655
Conventional Jet Fuel

Re-Certification NOT Required

Reference: Mark Rumizen January 25, 2010
Biofuel Developments
Renewable Fuels
Why Discuss This Now?
Business Aviation Commitments

• Through organizations like NBAA, GAMA and IBAC Business Aviation has committed to being good Stewards of the Environment.

• Press Release on November 24, 2009

• Commitment is based on 4 pillars
  – Improved Technology
  – Improved Infrastructure & Operations
  – **Use of Alternative Fuels**
  – Market Based Measures

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BUSINESS AVIATION AND CLIMATE CHANGE

Advocating for a global aviation sectoral approach in a post-Kyoto global framework

The global business aviation operating and manufacturing communities support the International Civil Aviation Organization’s (ICAO) proposal for aviation sectoral management of targets and monitoring of greenhouse gas (GHG) emissions in a post-Kyoto Agreement. We support the ICAO Programme of Action on International Aviation and Climate Change and are in accord with the Declaration of the High Level Meeting on International Aviation and Climate Change convened by ICAO in Montreal on 2-9 October 2009.

Our record of achievement
Business aviation has established an excellent record of consistently improving fuel efficiency, delivering 40% improvement over the past 40 years. Business aviation’s global CO2 emissions are approximately 2% of all aviation and 0.4% of global man-made carbon emissions. Business aircraft are operated for specific missions and fly efficient, direct routes between airports. Modern navigation equipment, combined with the latest technologies in aircraft and engine design and operational best practices, provide for ever-improving fuel efficiency and reduced GHG emissions.

Our commitment
Nonetheless, our community is resolved to do even more. Business aviation manufacturing and operating communities have jointly developed an aggressive programme in support of ICAO targets. Achieving these targets will require not only sustained effort on the part of the entire business aviation community, but also a partnership between industry and government, and the development of realistic solutions that balance economic growth, progress and technology. The business aviation community therefore commits to the following specific targets:

- Carbon neutral growth by 2020
- An improvement in fuel efficiency of an average of 2% per year from today until 2020
- A reduction in total CO2 emissions by 50% by 2050 relative to 2005

We will achieve these objectives through expected advances in four areas: technology, infrastructure and operational improvements, alternative fuels, and market based measures.

Consistent with ICAO recommendations and limitations on data availability, business aviation supports the development of an appropriate alternative metric within ICAO to measure and track business aviation emissions on a fleet basis.

Our needs
Given the global nature of aviation, internationally harmonized policies, rules and procedures are critical to ensure safe, efficient and balanced operations. Our community believes that ICAO must be assigned global sectoral responsibility over aviation emissions targets and monitoring.

Our promise
The business aviation sector has made remarkable improvements in its environmental performance over the last half century. The industry believes that if properly given to the aviation community to manage environmental stewardship in partnership with industry and under the leadership of ICAO, all will enjoy a vibrant and healthy industry that will continue to proactively reduce its impact on the environment even as demand for business aviation continues to grow.

www.ibaa.org  www.gama.aero
Who is pushing for Renewable Fuels in Aviation?
US Renewable Goals/Activities

• US FAA Aspirational Goal - 1 Billion Gallons of Renewable Jet Fuel by 2018 (estimated about 5% of total)

• FAA is standing up a Center of Excellence specifically for renewable Fuels
  – $40 million over the next 10 years
  – Covers more than just renewable fuels

• Farm-to-Fly 2
  – “Accelerate the availability of a commercially viable and sustainable aviation biofuel industry in the United States, increase domestic energy security, establish regional supply chains, and support rural development.”
  – Among others GAMA & NBAA are signatories
Military

- Via the Defense Production Act (DPA)
  - Asking for $510M over a three year period for cost competitive, advanced biofuels refineries
  - USDA, DOE and Navy ($170M each)
  - Congress pushing back

- Navy funded the Phase 1 winners to date (cost share development):
  - **Emerald Biofuels**, IL/LA: HEFA, plant and animal TAGs
  - **Natures BioReserve, LLC**, NE: HEFA, animal processing fats
  - **Fulcrum Bioenergy**, CA/NV: FT-SPK, MSW (and USDA loan commitment)
  - **RedRock Biofuels**, CO: B-GTL
Commercial Aviation Alternative Fuels Initiative

- 15 Aircraft, Engine, Subsystem OEM’s
- 19 Countries / 5 Continents
- 20 Airlines, Military, Airport orgs.
- 54 fuel producers
- 30 U.S. States / State Univ’s
- 15 U.S. States / State Univ’s
- 30 U.S. Government Offices
- 180 Different Organizations, 32 EXPO Participants
- 300 Global Sponsor/Stakeholder Attendees
What are the Advantages?
Renewable Fuels - Advantages

• Renewable fuels are a step change to reduce emissions
  – Less sulfur
  – Less aromatics (means less carcinogens)
  – Less PM2.5 (fine particle pollutant regulated by EPA - LAQ)

• Renewable fuels will likely be recognized within future economic measures/market based measures

• Typically have higher energy density

• Can be less CO$_2$ (life-cycle analysis – based on feed stocks and processing)
What does it mean to have less CO$_2$ emissions?
At The Fuel Level...What Does Improvement In CO₂ Emission Mean?

**Lbs of CO₂** = (lbs of Fuel) x 3.149

Jet A or Biofuel

**Not This!**

1,000 lbs of Fuel Saved is 3,149 lbs of CO₂ Saved

**Well-to-Wake GHG Emissions Bio-based Fuels**

**Life-cycle Improvement**
Life-Cycle Analysis indicates 60 – 80% CO₂ Emissions Improvement

Biofuel Based

Credit

Petroleum Based
What are the Challenges?
Challenges

- Today it is difficult to make renewable jet fuel at a competitive price
- Some fuel suppliers are motivated to only make renewable gas and diesel... not Jet-A
- Limited by the amount of available land for traditional crops and dedicated energy crops
Gulfstream Has a Good Start
G450 Biofuel Flight (2011)

5.5 tons of CO₂ Saved using Biofuel

G450 – 1st Aircraft to Make a Transatlantic Flight on Biofuel
NBAA Biofuel Flights (2012)

- All 5 In-Production Aircraft Flown To NBAA 2012 On 50/50 Blend of Biofuel & Jet-A
- Certified Fuel
- Camelina Based
- Supports Gulfstream’s Sustainability Efforts

1st OEM To Fly Its Entire In-Production Fleet To A Major Air Show On Biofuel
Much more to do.
You can do your part too!
Reducing CO$_2$ Emissions

• Improve the way you operate your aircraft
• Promote the improvement of air traffic management system
• Purchase fuel efficient aircraft...in the future you can check the CO$_2$ score for the aircraft
• Support sensible Market Based Measures that benefit the environment
• Promote appropriate renewable fuels for aviation
The Earth is not a gift from our parents, it is a loan from our children

Kenyan Proverb
Questions