



# Engine Exhaust Emissions Standards and Transition Goals to Standards

Curtis A. Holsclaw  
Manager-Emissions Division  
US Federal Aviation Administration



# Background



- Underlying ICAO CAEP principles for standard-setting
  - Technological feasibility
  - Economic reasonableness
  - Environmental benefits
  - Environmental interrelationships and tradeoffs
- Recognized that relationship between goals and standard-setting processes needed to be understood



# Background



- Standards currently address gaseous emissions of carbon monoxide (CO), oxides of nitrogen (NO<sub>x</sub>), and unburned hydrocarbons (UHC), and smoke
- Regulatory regime directly addresses emissions during the landing and take-off (LTO) cycle; a correlation has been shown between LTO and cruise, thereby an indirect control of emissions outside the LTO
- Standards do not currently exist for particulate matter (PM) emissions and carbon dioxide (CO<sub>2</sub>)
  - Research programs are developing PM emissions measurement and sampling procedures to characterize these emissions and understand their evolution
  - Incentives for reduced fuel consumption have obviated the need for a CO<sub>2</sub> standard



# Historical Perspective



- NO<sub>x</sub> stringency levels were chosen so as to encompass all existing engines in production, thus ensuring that for a given pressure ratio no newly manufactured engines would be more polluting than the worst present production model.
- Primary consideration was given to the best available engine technology, which embraced a broad range of engine categories as represented by the operating aircraft fleet.
- Focusing on proven application of best available engine technology over a broad range of engines ensured proper emphasis was given to operational safety concerns in selection of a stringency level.
- Incorporation of technologies that could not be currently certificated or that did not exist over a sufficiently broad range of production engines were not deemed appropriate to serve as the basis for standard setting. However, they were recorded as research goals.



# NOx Emissions Stringency Assessment at CAEP/6



- Working assumption agreed
  - “In the context of technology for improved emissions performance to be used as part of the basis for ICAO standard setting, technological feasibility refers to any technology demonstrated to be safe and airworthy, and available for application over a sufficient range of newly certificated aircraft.”



# Technology Readiness



- Use Technology Readiness Level (TRL) scale
- Transition from long term to medium term goals, to consideration of certification standards
- Agreement on transition points
- Recognized that goal-setting will involve some degree of judgment on the performance outcome that is likely through the development process dependent upon TRL demonstration



# Technology Readiness Scale

(Excerpted from CAEP/6-IP/4, Appendix A)

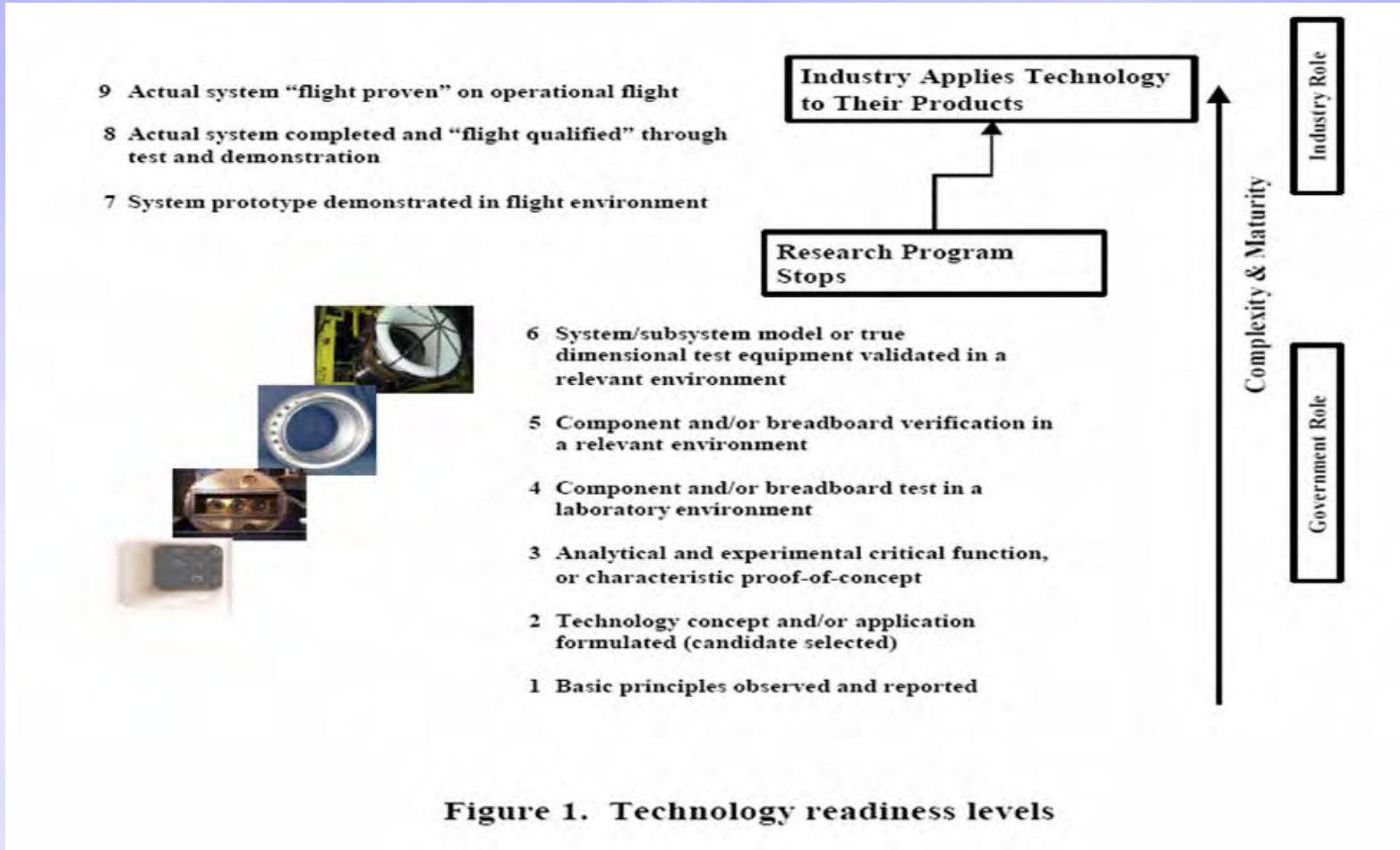


Figure 1. Technology readiness levels



# Technological Feasibility



- TRL8 is actual system completed and “flight qualified” through test and demonstration; note that TRL9 is “flight proven” on operational flight
- TRL7 is system prototype demonstrated in flight environment
- TRL6 is system or subsystem model or true dimensional test equipment validated in a relevant environment; this is the stage when research programs typically stop and industry applies technology to their products





# Transition Points



- TRL8 is the point at which technologies are deemed to be technological feasible in the context of ICAO standard-setting
- Technologies demonstrated up to and including TRL7 are appropriate for consideration in goal-setting processes



# Technological Feasibility



- "In the context of technology for improved emissions environmental performance to be used as part of the basis for ICAO certification standard setting, technological feasibility refers to any technology demonstrated to be safe and airworthy proven to TRL8, and available for application in the short term over a sufficient range of newly certificated aircraft. Technologies demonstrated up to and including TRL7 are appropriate for consideration in medium and long-term goal-setting and review process."



# Considerations



- A new standard will typically apply some 3-4 years (short term) after CAEP agreement so referencing TRL8 ("flight qualified through test and demonstration") draws in technologies already proven and either already certificated or about to be with EIS shortly thereafter.
- TRL 9 takes in only engines already in service and ignores the known introduction of further engine technology developments prior to the effective date for a new standard.
- Introduction of the goal-setting language acknowledges the basis for transition from goals to consideration of standards and provides for a logical link between short, medium and long-term timescales.



# Way Forward



- TRL scale will be used as the mechanism for judging the state of development of technologies that are considered under the goal and standard setting processes
- The transition from medium term technology goals to considerations for standard setting, based in-part upon technologies shown to have achieved such goals, is defined by technologies that have matured to TRL8 status
- Establishment of long term goals involves more uncertainty with regards to potential performance outcome and is farther removed from the standard-setting process
- During the CAEP/8 cycle there will be an assessment of technology status and environmental need to support consideration of increasing the stringency of the current NOx emissions standard



# Next Steps-CAEP/8



- Assess technology advances
- Monitor/review progress on NO<sub>x</sub> technology goals
- Conduct an updated emissions trends assessment, for baseline (w/forecasts), and various cases which consider technology and operational improvements; assess the contribution of CAEP policies toward influencing the forecasted emissions
- Analyze the technological response to a range of NO<sub>x</sub> stringency options up to CAEP/6 minus 20% at OPR = 30 for application no sooner than 2012
- Provide the necessary inputs to integrate technology responses and trade-offs into the CAEP benefit-cost modeling



# Standard Development

