Lecture	Title	Outline
L001	Thermodynamic basics, ideal & real cycles	Basic thermodynamics - Conservation of energy - Total and static quantities - Gas properties Thermodynamic cycles - Ideal Joule process - Real Joule process - From turboshaft to turbojet and turbofan
L002	How Performance Programs Work	Performance program examples Numerical technique applied to off-design simulations Some special details
L003	Getting started with GasTurb 13 - cycle design	A life demo of simple and more advanced program features - Single design point input and output - Enthalpy-entropy diagrams - The formula editor (composed values) - User-defined additional iterations
L004	Getting started with GasTurb 13 - off-design	A life demo of simple and more advanced program features - Single point off-design input and output - Operating line - Deterioration modeling - Control system simulation (limiters) - Compressors with variable guide vanes - Map scaling
L005	Turbojet off-design	Turbojet components - Compressor - Burner - Turbine - Nozzle Cooperation of components - Nominal performance - Modifiers
L006	Turbofan off-design	Turbojet as Gas Generator Variable guide vanes Turbofan - Fan - Booster - Low pressure turbine
L007	Compressor performance 1	Compressor Basics - Work and flow coefficient - Torque Measuring compressor maps What's hidden in a map Map reading

L008	Compressor performance 2	Compressor performance - Variable guide vanes - Reynolds correction - Map selection - Map extension to low speed - Map scaling
L009	Getting started with Smooth C	A life demonstration - Data input: reading from a bitmap - Defining the ß-line grid - Selecting a reference point - Working on mass flow - Working on efficiency - Checking the final map
L010	Turbine performance	- Expansion process - Efficiency - Modeling a cooled turbine - Secondary air system - Turbine flow capacity - Turbine map format
L011	Measurements	- Test facilities - Instrumentation - Accuracy requirements
L012	Traditional test analysis methods	Core flow analysis Correction to standard conditions More data corrections - Thrust correction - Humidity - Condensation in the inlet
L013	Model-based test analysis	- Comparison of analysis methods - AnSyn factor calculation - Model-based analysis examples - Model-based analysis in industry
L014	How to create a model (J57)	Sources of data Principle of the model creation process Model creation example (J57)
L015	Building a model of the LM2500	Checking the data Cycle reference point Off-design with GasTurb standard maps Selecting a map reference point Editing the compressor map in GasTurb 13 and Smooth C Low pressure turbine map
L016	Building a model of the PT6A-67R	Cycle reference point Handling bleed model Comparison with measurements
L017	Siemens SGT6-8000H	Available data Secondary air system Model creation Model application Combined cycle

L018	Modeling the CFM56-3	Check of the data - Bellmouth - Thrust - Temperatures - Fuel flow 0-D Performance simulation - Component maps - Comparison wih measurements
L019	Modeling the Siemens SGT800	Principle of the model creation process - Cycle reference point - Off-reference simulation . Estimating the compressor map . Estimating the turbine map
L020	Fundamental design decisions	Preliminary design Objectives and tools From thermodynamics to geometry Questions to be answered Example: Single versus two stage HP turbine
L021	Conventional and geared turbofan	Fundamental differences between conventional and geared turbofans - Common core, corrected flow W2Rstd=25kg/s - Burner exit temperature = 1875K - Overall pressure ratio =43.9 Bypass ratios 6 - 12 (conventional), 12(with gear) - 18
L022	Preliminary design of aircraft engines	- Objectives and tools - From thermodynamics to geometry - Questions to be answered - Example: Fundamental differences between conventional and geared turbofans
L023	Preliminary design of aircraft engines with GasTurb 13	Flow annulus - Mach number @ stations are important - The geometry editor - Conceptional design Compressor mean line analysis - Comparing with a given cross section
L024	Starting and windmilling	Idle ratings Ground starting simulation (turbojet) - Begin of a start simulation - Cranking (no fuel) - Sub-idle acceleration Windmill relight

L025	Getting started with Smooth C and Smooth T	Smooth C - Data input: reading from a bitmap - Defining the ß-line grid - Selecting a reference point - Working on mass flow - Working on efficiency - Checking the final map Smooth T - Defining the ß-line grid - Selecting a reference point - Mass flow and efficiency - Turbine exit flow angle
L026	Turbine performance 1	- Expansion process - Efficiency - Modeling a cooled turbine - Secondary air system
L027	Turbine Performance 2	- Flow capacity - Turbine map format - Weight
L028	Nozzle performance	Convergent nozzles - Discharge coefficient - Thrust coefficient Convergent-divergent nozzles - Theory - Reality - Implementation in GasTurb
L029	Transient operation 1	Some basic theory - Thermal effects Heat soakage Tip clearance
L030	Transient operation 2	Transient control Transient simulations with GasTurb - Spool inertia - Heat soakage and tip clearance
L031	Inlet flow distortion	Types of inlet flow distortion Distortion coefficient DC60 Parallel compressor theory Two compressors in series (compressor coupling) Changes in performance due to distortion
L032	High speed propulsion	Point performance - Turbojet - Turbojet with reheat (afterburner) - Turbofan with reheat - Ramjet - Size considerations Acceleration to high Mach numbers
L033	Turboshaft design	Turboshaft configurations Mission analysis Design point selection Margins

L034	Turboshaft off-design	Off-design behavior of a gas generator Single compressor turboshaft model Two compressor turboshaft model - Booster operating line - Handling bleed
L035	Getting started with Smooth T	Defining the ß-grid Selecting a reference point Working with mass flow and efficiency Re-shaping a map Maps for engine start and windmilling simulation Theoretical considerations
L036	Power management	Thrust management options - Fully rated engines - Thrust rated engines Helicopter power management The throttle lever - Rating schedules - Rating adjustments
L037	Compressor map extension	Extrapolation to low pressure ratio Compressibility effects Adding lines for low speed The speed line zero Example
L038	Parametric studies and optimization	Thrust growth of a business jet engine - Baseline engine - Growth engine configuration - Design constraints - Numerical optimization
L039	Engine families	Motivation for an engine family Examples of engine families Options for an engine family Thrust growth study
L040	Corporate vs regional aircraft propulsion	Corporate vs regional aircraft engines Aircraft thrust requirements Engine models Cycle summary Conclusions
L041	Secondary air system	Internal vs external air systems Air system design Secondary air system in performance
L042	SFC of turbofans - facts and visions	Thermal efficiency of the Joule cycle Efficiency definitions: propulsive, core, transmission, overall, SFC SFC predictions and visions
L043	Humidity and water injection	Humidity - Gaseous humidity - Inlet condensation Fogging Water and steam injection Anti icing

L044	Turbojet thrust growth	Turbojet engine limitations Turbojet growth options - Turbine and nozzle adjustment - Temperature increase - Variable compressor geometry - Adding compressor stages
L045	Turboshaft and turbofan thrust growth	Off-Design behavior of the gas generator Growth with a booster - Common core engines - Booster operating line Turbofan - Unmixed flow - Mixed flow
L046	Thrust control	Military engines - Thrust rating Commercial engines - Limitations on maximum thrust - Thrust setting parameters - Rated thrust levels
L047	Cycle variants 1	Efficiency potentialSingle spool engine: Alstom GT13E2 Two spool engine: GE MS5002 Sequential Combustion: Alstom GT24/GT26 Intercooled engine: GE LMS100
L048	Cycle variants 2	Intercooled and recuperated engines - Example: RR WR-21 - Turbofan Two versus three spool engines Puls detonation engines
L049	Aircraft propulsion	Thrust Quality criteria - Propulsive efficiency - Thermal efficiency - Transmission efficiency - Overall efficiency, SFC Mission analysis
L050	Component design 1: compressor and combustor	Compressor - Axial and radial - Efficiency - Size Core size Combustor
L051	Component design 2: Turbine, mixer, afterburner, nozzle	Turbine - Aerodynamics - Efficiency definitions Mixer Afterburner Nozzle
L052	Thrust-in-flight analysis	Thrust-drag bookkeeping - Control volume - Installed propulsive force Eurofighter TIF methodology

L053	Engine health monitoring	Detection of engine faults The performance analysis task - Challenges - Methods Gas path analysis MTU engine health monitoring
L054	Open rotor engines	Open rotor engine configuration Counter rotating propeller Modeling the GE36
L055	Inlet flow distortion and transient operation	Inlet flow distortion - Parallel compressor theory - Distortion coefficient DC60 - Distortion effect on performance Transient performance - Control options - Engine geometry model - Transient tip clearance - Heat soakage