Technical Quarterly Progress Report - Advanced Gas Turbine Systems Research

Quarterly Report
April 1 - June 30, 1997

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Federal Energy Technology Center
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SUMMARY

Major Accomplishments by AGTSR during this reporting period are highlighted below and amplified in later sections of this report:

Administrative

- AGTSR's five-year renewal proposal was approved by DOE-FETC and DOE-HQ's extending the program until the Year 2001
- AGTSR received the balance of funds for 1997 from DOE-FETC to cover the period June 13, 1997 to December 31, 1997 – the amount was for \$2,367,000 bringing the total to \$4M for FY97
- AGTSR provided a list of potential reviewers to DOE-HQ and DOE-FETC for SBIR proposals in the areas of sensors / controls and combustion
- AGTSR set the date for the 1997 Industry Review Board (IRB) proposal review meeting for September 4-5, 1997 at Clemson
- AGTSR Newsletter No. 7 was released in April 1997
- AGTSR prepared 9 new subcontracts from the 96RFP with a planned start-date of June 13, 1997
- AGTSR released 21 intern applications to the IRB for review and rank-ordering

- AGTSR selected 17 new interns to work at IRB company sites starting in June 1997 – subcontract packages were negotiated for all 17 interns
- AGTSR prepared subcontract amendments for the active 1995 projects to carry them into the third year of research
- AGTSR submitted information to DOE-FETC on an active combustion control senior manager's meeting hosted by the Navy - China Lake
- AGTSR distributed information to the IRB on a new materials database that may support ATS needs

Research

- AGTSR participated on the ATS panel at the 1997 IGTI TurboExpo highlighting research collaborations within the AGTSR consortium
- AGTSR displayed an exhibit booth at the 1997 IGTI TurboExpo showcasing their latest research results and program announcements
- AGTSR distributed to the IRB and DOE two research reports from Clemson University's film-cooling project
- AGTSR received 63 Intent to Propose forms as a response to the 1997 RFP announcement: 13 in materials, 27 in heat transfer, and 23 in combustion
- AGTSR evaluated two advanced sensors Phase I SBIR proposals for DOE-HQ's
- AGTSR toured the GE-Greenville gas turbine plant and discussed research and education opportunities with their heat transfer group
- AGTSR provided to DOE-FETC a tentative agenda for the AGTSR research poster session for the 1997 ATS Annual Review Meeting
- AGTSR distributed MIT's final report on internal heat transfer research to the IRB and DOE

- AGTSR participated in UConn's thermal barrier coatings partners meeting to discuss research results and collaboration with industry
- AGTSR awarded 9 new subcontracts selected from the 96RFP solicitation
- AGTSR submitted an abstract on catalytic combustion research for the 1998 AGARD meeting in Portugal
- AGTSR received and logged in 52 research proposals in response to the 1997 RFP: 22 in combustion, 20 in heat transfer, and 10 in materials
- AGTSR distributed the 95-01 semi-annual progress reports to the IRB and DOE
- AGTSR initiated collaboration with NASA-Lewis on their aero-propulsion university research program
- AGTSR distributed three final reports from Texas A&M, Lehigh, and Penn State to the IRB and DOE

Workshops/Education

- AGTSR distributed the proceedings (two volumes) from Heat Transfer Workshop II
- AGTSR presented a paper at the 1997 IGTI TurboExpo on the status of its educational internship program with industry
- AGTSR placed 17 interns at IRB company sites as part of the educational mission of the AGTSR consortium
- AGTSR initiated a trial sabbatical program with Clarkson University and Pratt & Whitney in West Palm Beach, Florida
- AGTSR released a short course brochure on film-cooling and also advertised the course in the International Turbomachinery publication
- Brigham Young University, an AGTSR subcontractor, hosted a one-day combustor code workshop on June 24, 1997

Membership

- Two new universities expressed interest in becoming AGTSR performing members: Rensselaer Polytechnic Institute and the University of Tennessee
 - For 1997, AlliedSignal Engine Company withdrew membership in the AGTSR consortium due to corporate budget cuts
 - Two companies expressed interest in becoming affiliate members of the AGTSR consortium: Fluent and Southern Company Services
-

Membership

During this reporting period, the following institutions became AGTSR Performing Members: Rensselaer Polytechnic Institute and the University of Tennessee. AGTSR membership is currently at 90 schools, representing 37 states.

Fluent, Inc. expressed interest in possibly becoming an affiliate member of the AGTSR Consortium. Fluent markets advanced computational software that may be used to analyze problems in gas turbine heat transfer, combustion, and materials processing. AGTSR sent a formal invitation to Fluent during this reporting period. The point-of-contact for Fluent is Dr. Tom Norton who indicated to AGTSR that they are giving it serious consideration and a final decision will be made by the end of July 1997.

An invitation to join AGTSR was also sent to Southern Company Services in Birmingham, AL. The point-of-contact there is Charles Boohaker of the Power Technology Division. Charles indicated that they are interested in combustion research and the internship program and may become a member either this year or next year on a trial basis.

The Eldim Company was also invited to become a non-voting, industrial affiliate member of the AGTSR Consortium. AGTSR's contact there is George Bontaites and they are interested in catalytic substrate technology for advanced industrial gas turbines.

David Winstanley, the AGTSR focal point for AlliedSignal, indicated that they had some significant budget cuts in FY97 and as a result could not remain as active members in FY97, especially since they were not direct industrial partners of the ATS prototype program. David did say that they will try to reinstate membership in 1998, since they are very interested in the mission and leveraging of the AGTSR research projects.

In 1993 through 1996, AGTSR received cost-sharing contributions of \$25,000 from each of the IRB members. The IRB now consists of six U.S. turbine engine/component manufacturers with EPRI and GRI continuing to act as utility and industrial gas turbine advisors for AGTSR. As of this date, all the IRB members, with the exception of GE, have paid their annual contributions for 1997.

1993-through-1996 Subcontract Progress

Brigham Young University, which is a four year effort, received a no-cost extension until December 31, 1997. Final reports from MIT, Texas A&M, Penn State, and Lehigh University have already been received and distributed to the IRB. MIT's project was terminated a year early by the IRB, therefore, they only reported

on the aerodynamic measurements using Particle Image Velocimetry (PIV) to obtain planar velocity profiles in a rotating, internal passageway. The corresponding heat transfer study, Phase II of the project, will not be supported by AGTSR, but MIT has promised AGTSR access to these results when completed. Texas A&M's project dealt with the effects of rotation on cooling passage heat transfer with different enhancement geometries, and the effects of TBC spallation on surface heat transfer. Also, in their unsteady aerodynamics study, they developed an unsteady transition model and correlations which were implemented into a heat transfer calculation code. The Penn State project developed a thermo-mechanical-fatigue (TMF) crack growth model and a new life prediction model to account for thermomechanical strain cycling under realistic conditions. The Lehigh project focused on producing advanced TBC's using two Functionally Graded Materials (FGM) production methods - Reaction-Bonded Metal Oxide (RBMO) and electrochemical processing.

The following final reports are due next quarter: Berkeley, Louisiana State, Purdue, and VPI. Also, additional funding support for Professor Ron LaFleur of Clarkson University has been approved. Effective July 1, 1997, Ron will be doing a one-year sabbatical at P&W/ West Palm Beach in conjunction with an AGTSR intern student that will work with Ron for 10 weeks during the summer of 1997. Ron will be working on some longer term research projects in the aero-heat transfer area in coordination with Fred Soechting and Mark Zelesky of P&W.

The FY95 AGTSR semi-annual progress reports have all been received and were distributed to the IRB and DOE-METC in June, 1997. The Clemson FY94 (film-cooling research project) annual and semi-annual reports (over a year delinquent) have now been received and reviewed by the IRB. The IRB approved both reports and as a result their outstanding invoices and amendments are being processed by the AGTSR accountant.

The FY94 final reports are due during the fall of 1997. The following FY94 projects are still active: Purdue, Cal-Irvine, Minnesota, Carnegie Mellon, Clemson, Georgia Tech, Maryland, and Oklahoma. No-cost extensions have been approved for UC Irvine and Minnesota until November 30, 1997 and December 31, 1997, respectively.

The AGTSR Industry Review Board (IRB) has selected nine new research projects from the 1996 RFP solicitation. DOE-FETC has approved these nine new projects, and since full FY97 support has recently been secured, the nine new subcontracts have been awarded with an effective start-date of June 13, 1997. These new projects are from the following universities: Cal-Davis (aerodynamics), Cleveland State (TBC's), Cornell (combustion), MIT (aerodynamics), Northwestern (TBC's), Penn State (combustion), Pittsburgh (TBC's), Purdue (combustion), and Wisconsin (aero-heat transfer).

FY97 Budget and AGTSR Renewal Proposal

AGTSR's 5-year renewal request to continue the AGTSR consortium until the Year 2001 has been approved technically and programmatically by both DOE-HQ and DOE-FETC. In the interim, until the renewal agreement was signed off by DOE, two contract extensions were let out to AGTSR amounting to \$1.6M, to extend the program until June 30, 1997. Recently, the renewal agreement was executed and DOE-FETC provided AGTSR with the balance of funds for 1997 covering the period June 13, 1997 to December 31, 1997. This amount was for \$2.4M, bringing the total to \$4M for FY97. With this new funding support from DOE, AGTSR was able to execute the nine new 1996 awards, the 1997 summer interns, and the research continuations for the FY95 subcontracts.

Status of the 1997 RFP Solicitation

On May 30, 1997, AGTSR received 52 proposals in response to the 1997 RFP solicitation: 22 in combustion, 20 in heat transfer, and 10 in materials (thermal barrier coatings). The attached spreadsheet lists the proposals by technology area. The 1997 RFP represents AGTSR's fifth announcement. These proposals will be reviewed by the IRB during the summer and the IRB Proposal Review Meeting is scheduled for September 4-5, 1997 at SCERDC. This year's review meeting was reduced to two days, as the detailed proposal reviews and evaluations will be conducted beforehand by industry. As agreed by the IRB, the technical R&D representatives of each company will spend the first day discussing the merits of the top proposals. The second day will focus on voting and selection by the IRB focal points. An agenda for the IRB meeting will be forthcoming in early August 1997. Proposals selected for funding from the 1997 RFP will probably be announced in the fall of 1997. AGTSR anticipates enough funding in FY98 to initiate another 6-9 new awards with a start-date of January 1998.

AGTSR's Second Heat Transfer Workshop

The proceedings for Workshop II were released last month to all the participants. It consisted of two volumes including a short summary by the Clemson University technical hosts of the key points brought forth during the Workshop. Edge-cooling heat transfer in the endwall, trailing edge, and

blade-tip regions was emphasized by industry as being a very important area to pursue during the next few years to support ATS and future programs; and as a result, this topic was listed in AGTSR's 1997 RFP announcement. The majority of the participants recommended that AGTSR host the heat transfer workshop on an annual basis, or at least every eighteen months. Consequently, AGTSR is considering their next workshop for the early Fall of 1998, hosted either with Clemson again or the University of Texas at Austin. If interested in obtaining a copy of the proceedings for Heat Transfer II, please contact Ms. Donna Kelly, 864-656-2267.

Combustion Workshop IV with Georgia Tech

Another productive combustion workshop for AGTSR took place on March 5-7, 1997 in Atlanta, GA, co-hosted with Professor Ben Zinn of Georgia Tech. The proceedings for this workshop are nearing completion and should be available for distribution by the end of July 1997. The industry-university interactions were substantial and were especially lively in the catalytic combustion session, which is considered an enabling technology to satisfy the ultra-low NOx emissions capability for advanced land-based gas turbines. The AGTSR combustion workshop will be held on an annual basis. Planning for Combustion Workshop V is underway with our co-host being Dr. Robert Dibble of UC-Berkeley in California. The dates are set for March 25-27, 1998 at the Berkeley Marriott facility. If you did not attend Combustion IV and would like a copy of the proceedings, please contact Ms. Donna Kelly at SCERDC, 864-656-2267.

AGTSR Distributes Film-Cooling Short Course Brochure

In June 1997, AGTSR distributed the registration brochure advertising our first short course for the AGTSR program. The course is for 2-days and is scheduled for August 6-7, 1997 at Clemson's Madren Conference Center. There will be five instructors: three from academia and two from industry. The course content offers a combined experimental and computational approach that explains the important processes and physics associated with state-of-the-art and advanced film-cooling designs. AGTSR anticipates 15-20 people to register for the course as several from government, academia, and industry have expressed interest in attending. There is still time to register. If interested, please contact Ms. Angie Justice, 864-656-2267.

BYU Holds a One-Day Modeling Workshop

On June 24, 1997, Brigham Young University (BYU) conducted a one-day gas turbine combustor code workshop. This workshop was offered in partial fulfillment of the work statement for their AGTSR contract. Several industry representatives from each of the major ATS manufacturers were in attendance. The following topics were covered at the workshop: turbulent combustion methods, control-volume finite-element methods, new reduced mechanisms for lean premixed combustion, velocity-scalar PDF method, code input-output and evaluation, sample problems and hands-on experience. BYU's code will be made available for testing on various computer platforms for industry, and the workshop attendees will also receive copies of a new databook containing laser-based measurements (velocity, temperature, and composition) of lean, premixed combustion of natural gas obtained in the BYU laboratory-scale gas turbine combustor facility. For additional information on this workshop, please call Dr. Scott Brewster of BYU at 801-378-6240.

AGTSR Submits Abstract for 1998 AGARD Meeting

AGTSR submitted an abstract for consideration for presentation at the AGARD Symposium on Gas Turbine Engine Combustion, Emissions, and Alternative Fuels. The AGARD Symposium is scheduled for October 12-16, 1998 in Lisbon, Portugal. The abstract was entitled: "The Status of Catalytic Combustion R&D within the ATS Program." This paper will present a summary of the projects and key results achieved pertaining to the catalytic combustion activity within the Advanced Turbine Systems (ATS) program. The status of the partnership between Catalytica and the three OEM's; GE, Allison Engine Company, and Solar Turbines will be discussed. In addition, Westinghouse's relation with Precision Combustion, Inc (PCI) will be highlighted. Research issues on premixer design, combustor dynamics, and durability of catalytic combustion systems will also be presented. This symposium is being organized by Klaus Schadow of the Navy in ChinaLake, California.

AGTSR Places 17 Interns at ATS Company Sites

For this summer, starting in June 1997, AGTSR placed 17 interns at ATS company sites to gain hands-on, practical experience in an industrial setting. 21 applications were received this year from the 90 AGTSR performing members. The IRB reviewed and rank-ordered the applications in April 1997 and AGTSR announced the selection of interns in May 1997. AGTSR sees the Industrial Internship Program as a motivational factor for engineers to encourage research and education in gas turbines, define relevant research projects, and provide an opportunity to see various engineering career paths in design, testing, R&D, and advanced technology. To date, AGTSR has placed 37 interns at ATS industrial sites. Of the 17 interns placed this summer, 6 were in the combustion area, 7 in heat transfer, and 4 in CFD/ materials. The interns will finish their 10-week tour in mid-to-late August and they are required to give an oral presentation to industry on their technical accomplishments and the value of the program relative to its research and educational merit. AGTSR also receives a written, 3-5 page summary report from each intern.

AGTSR Participates in the 1997 IGTI TurboExpo

AGTSR participated in three ways at the TurboExpo in Orlando, FL this summer: displaying an exhibit booth on the AGTSR consortium, presenting a paper in the education session, and taking part in an ATS panel session. The exhibit booth displayed some of the research successes of AGTSR in the various discipline areas: combustion, aerodynamics, heat transfer, and materials. Some hardware items, such as combustion sensors and heat pipe cooling vanes, were also displayed at the booth. The AGTSR paper was entitled: "AGTSR: A Unique Gas Turbine Consortium." The paper emphasized both the educational and research missions of AGTSR. It also highlighted the status of the consortium and discussed the effectiveness and impact of the industrial internship program which targets graduate-level students within the AGTSR performing members. In the ATS panel session, AGTSR discussed their unique role in support of ATS and provided some examples of successful research collaboration with industry and universities as fostered by the AGTSR consortium.

Miscellaneous Activities

AGTSR plans to release their 8th newsletter in November 1997. This newsletter will highlight AGTSR's participation in the ATS Annual Review Meeting, present some of AGTSR's recent research successes, and will summarize the results of the 1997 RFP selection as well as the 1997 Industrial Internship Program that placed 17 interns at company sites during the summer.

AGTSR plans to have a poster session at the ATS Annual Review Meeting in Morgantown, WV, October 28-29, 1997. A tentative agenda that includes 29 research posters has already been submitted to DOE-FETC's conference services office who are organizing the ATS Review this year.

An AGTSR program review at DOE-FETC is being scheduled for sometime in August 1997. The purpose of the review is to brief the DOE-ATS team on the SCERDC organization, the AGTSR proposal review process, AGTSR technical successes, and the future role of AGTSR and SCERDC after ATS comes to completion.

AGTSR plans to participate in Forum '97 offered by Concepts ETI, Inc from August 11-15, 1997. Concepts ETI is located in White River Jct, VT. The purpose of the Forum is to promote critical thinking in the gas turbine area to better plan future business strategies, develop turbomachinery products for the global marketplace, and refocus R&D into the next century. Forum '97 consists of three main sessions: Advanced Technology for Turbomachinery, CFD for Advanced Turbomachinery Products, and Hybrid Electric Vehicles with Turboalternators. On a no-cost basis, SCERDC has developed a working relation with Concepts ETI to share information on newsletters and related workshops and meetings.

AGTSR also plans to attend the Sensors and Controls Workshop offered by NIST, August 25-26, 1997, in Gaithersburg, MD. The purpose of the workshop is to discuss the measurement, sensor, control and robotic needs of both the power generation and process industries as supported by DOE-OIT. The technical sessions in this workshop should also support a new initiative in sensors and controls being considered by DOE-FETC and ORNL.

AGTSR RFP 97-01 BREAKOUT						
TECHNICAL AREA: Combustion						
Prop. No.	Submitted By/PI	Technical Objectives	No. Years	Total \$K	1st Year \$K	Industry Collaboration
C1	OKLA/ Gollahalli	Liquid Atomization, Vaporization and CI in Swirling Flows	3	420	140	DiversiTech, Inc. and Parker Hannifin
C2	Vanderbilt/ Mellor	Engineering Models and Datum Bases for GT's	3	733.73	231.396	University of Washington, Hughes Associates
C3	CalTech/ Culick	NonUniformities of Mixture Ratio in Lean PM Combustors	3	390.2	128.6	UC- Berkeley - Dibble's Probe, Aerospace Corporation
C4	BYU/ Fletcher	Interactions of Heat Release, Emissions, and Instabilities	3	431.799	140.5	ATS Working Team, Cost-Sharing with BYU/ Industry
C5	ASU/ Lee and Peck	Flashback and Autoignition in Lean PM Gas Turbines	3	298.86	101.134	AlliedSignal, Penn State University
C6	Clarkson/ Ahmadi	Fuel Spray Droplet Deformation/ Breakup	3	318.885	108.07	NASA-Lewis
C7	TexasA&M/ Caton	Emissions and Stability Studies of Gas Fired Burners	3	299.045	101.981	Texas A&M Industrial Consortium
C8	Purdue/ Gore	Combustion Diagnostics: UV, Visible, and IR Sensing	3	361.011	111.653	GRI, Ametek, Westinghouse, Allison
C9	VPI/ Vandsburger	Reduced-Order Models for CI Prediction	3	603.397	201.812	University of Virginia, DOE-FETC, Solar Turbines
C10	UCBerkeley/ Dibble	Low Acoustics Combustion: Autoignition and Flashback,	3	771.58	261.575	ATS Companies, DOE-FETC, Catalytica
C11	USoCal/ Ronney	Stability Limits and Emissions Characteristics of LP Flames	3	405.814	146.124	Departmental - Internal at USC
C12	Vanderbilt/ Pitz	Medium BTU Gas Fueled Turbulent LP Combustion	3	270.765	88.528	Sandia National Laboratory
C13	PSU/ Santoro	Design Methodologies to Suppress Combustion Instabilities	3	626.619	205.082	GEAE, GE-CRD, DOE-FETC
C14	Yale/ Pfefferle	Degradation Processes of Pd Catalysts	3	453.271	165.224	PCI, Westinghouse, Solar, DOE
C15	Maryland/ Gupta	Fuel Property, Swirl and Flow Distribution Effects	3	449.963	147.439	Morgan State (HBCU), P&W, Allison, Solar, GE
C16	Maryland/ Gupta	Liquid Fuel Flow Modulation and Swirl Effects	3	484.703	164.199	Clark Atlanta (HBCU), P&W, Allison, GE
C17	RPI/ Rusak	Instabilities in Combustion Systems	3	507.465	215.621	RPI Math Dept, ATS Industry
C18	Illinois/ Aggarwal	Investigation of Autoignition Characteristics of Liquid-Fuel	3	409.035	157.803	SUNY, P&W (UTRC), U CAL - SD, GE
C19	Lehigh/ Levy	Fuel Composition Effects on Autoignition	2	371.107	194.564	DOE-FETC, MK Engineering, P&W
C20	UCIrvine/ Samuelsen	Critical Technology Combustion Issues	3	696.116	235.114	All the ATS Companies
C21	UCSD/ Cattolica	Measurement and Prediction of NOx and CO Emissions	2	607.106	300.441	Solar Turbines, Yale University
C22	PSU/ Boehman	Influence of Fuel Quality on Hybrid Catalytic Combustion	3	440.54	141.095	DOE-FETC, Catalytica, , Los Alamos, Allison

Proposals listed in random order - they are not ranked.

AGTSR RFP 97-01 BREAKOUT						
TECHNICAL AREA: Heat Transfer - Edge Cooling						
Prop. No.	Submitted By/PI	Technical Objectives	No. Years	Total \$K	1st Year \$K	Industry Collaboration
H1	PENNST/ Yavuzkurt	Hydrodynamic and Turbulent Heat Transfer in TE	3	310.17	95.873	Pratt & Whitney, CT
H2	CenFL/ Kapat, Kassab	Investigation of Heat Transfer in the Blade Tip Region	2	368.288	136.128	Westinghouse, GE, Solar, Wright Lab
H3	MIT/ Guenette	Heat Transfer Aspects of Tip Clearance Flow	3	397.227	116.305	ABB, NASA-Lewis
H4	CMU/ Chyu, Simon	Nozzle Endwall Region: Experiments and CFD	3	559.971	190.461	UMinnesota, P&W, Solar, GE, Westinghouse
H5	ASU/ Fisher	Control of Vortical Flow and Heat Transfer in the Endwall	2	182.396	94.079	AlliedSignal, Northern Arizona Univ., University of Colorado
H6	OSU/ Dunn	Blade Tip and Platform Heat Transfer in Full Scale Turbine	2	382.618	186.715	Air Force
H7	Texas A&M/ Lau	Turbine Blade and Endwall Heat Transfer	3	322.129	130.649	NASA-Lewis Research Center
H8	Texas A&M/ Han	Unique Turbine Blade Tip Heat Transfer and Cooling	3	474.70	154.128	GE-CRD, GEAE
H9	Purdue/ Fleeter	Turbine Blade Tip, Endwall and Platform Heat Transfer	3	573.602	194.746	Allison Engine Company
H10	Purdue/ Plesniak	Airfoil Trailing Edge Cooling	3	460.183	165.308	Allison Engine Company
H11	NthEastern/ Taslim	Measurements of Heat Transfer Coeff. on a Blade Tip	1	99.406	99.406	GEAE, GEPS
H12	Clemson/ Leylek	Coupled External Aero and Internal Flow Analysis	3	415.679	130.773	GE - Greenville
H13	UCinn/ Sajben	Heat Transfer Coefficient Measurements Over TE	2	338.963	172.475	GE-CRD, GEAE
H14	VPI/ Diller	Effects of Tip Gap on Turbine Blade Tip Heat Transfer	3	195.859	65.081	GE, NASA-Lewis
H15	USC/ Dutta	LE and TE Endwall Heat Transfer - Endwall Gap Study	3	291	97	GE-Greenville, Allison, AlliedSignal
H16	UConn/ Langston	Heat Pipe Turbine Vane Cooling	2	142.852	70.016	Pratt & Whitney, CT
H17	U Minn/ Goldstein	Edge Cooling Heat Transfer on Turbine Blades	3	168.788	497.316	Howard Univ, GE, P&W, and Westinghouse
H18	Wisconsin/ Amano	Simulation of Secondary Flows Leading to Improved Blades	3	441.973	145.184	Siemens, STI, Taipower, Iwate University
H19	LSU/ Acharya	Trailing Edge and Tip Cooling	3	376.661	124.171	NASA-Lewis, Allison, P&W
H20	TexA&M/ Schobeiri	Unsteady Aero and Tip Clearance Flows	3	296.943	96.181	NASA, GE, In-house Facilities

Proposals listed in random order - they are not ranked.

AGTSR RFP 97-01 BREAKOUT						
		TECHNICAL AREA: Coatings (TBC's)				
Prop. No.	Submitted By/PI	Technical Objectives	No. Years	Total \$K	1st Year \$K	Industry Collaboration
M1	WAYNEST/ Newaz	Durability Assessment of TBC's using Thermal Waves	2	150.613	74.485	Westinghouse, GE, and ORNL
M2	CentralFL/ Desai	NDE of TBC's by ElectroChemical Impedance	2	198.619	103.446	Westinghouse, NASA-Lewis
M3	CentralFL/ Desai	Impact of Cooling Hole Oxidation on Heat Transfer	2	296.32	146.78	Westinghouse, ORNL
M4	UCSB/ Levi	Life Prediction and NDE for TBC's	3	599.94	199.99	Westinghouse, GE, Solar, Chromalloy
M5	Kentucky/ Reucroft	Structure-Property Relationships for TBC's	3	467.224	155.438	GE, ORNL
M6	GT/ Hampikian	Improvements in TBC's via Combustion CVD	3	441	145.952	GEPS
M7	U Conn/ Begley	Generation of Fundamental TBC Properties	3	459.515	148.432	ATS, Coating Suppliers, NIST, NASA-Lewis
M8	U Kentucky/ Davis	Impact of Zirconia Preparation on Quality of TBC	3	441.387	68.847	(note: 1st year is for 4mths) Inco Alloys, ORNL, Argonne, SUNY
M9	PSU/ Zamrik	Crack Growth Properties of TBC's	3	598.644	196.327	NASA-Lewis, Westinghouse, ORNL, P&W, Praxair, UConn
M10	PSU/ Simkovich	Novel Concepts in TBC Bond Coat Chemistry	3	428.2	139.415	Howmet, Sermatech International

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