Request for Proposal of
Recuperated Micro Turboshaft Engine
(KATS-100R)
Technical Consulting

2017. 2. 20

KOREA AEROSPACE RESEARCH INSTITUTE

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1 General Information

1.1 Project Information

The recuperated Micro Turboshaft Engine (KATS-100R) research project launched in late 2015 is a basic technology R&D project led by Korea Aerospace Research Institute funded by the ROK government. This project initiated by the needs of replacing reciprocate engines for small UAS by micro gas turbine engines. The goal of the project is to develop two key engine components, recuperator and reduction gearbox, and to establish an engine design process at KARI. KARI, as a system designer, will develop a rubber engine and shall provide components development and installation requirements. The two components are under development and their prototypes will be tested within two years. At the end of the project, KARI will make a physical mockup based on the engine design result, and install the developed recuperator and the reduction gearbox on it.

KARI is the system designer and leading organization. There are two Korean companies to develop and test reduction gearbox. One Korean company which develop recuperator and test with KARI. Hanwha Techwin involves as a layout designer and lead engine detail design for the component installation purpose.

This technical consulting will support establishing a turboshaft engine designing process in KARI and review preliminary engine design result for the project.

1.2 Schedule and process

1.2.1 Project schedule

This consulting is planned to assist the Project PDR in the 1st quarter of 2017.

Table 1 Project schedule

Year	2016				2017				2018			
Quarter	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Milestone		SDR				PDR		CDR				TRR

1.2.2 Consulting schedule and location

Table 2 Consulting schedule

Step	Event	Time
1	Remote design review	Mid of April, 2017
2	Technical consulting and design	Mid of May, 2017
3	On site design review	Early of Sep, 2017

1.2.2.1 Remote design review **shall** be finished and submit the review report within two weeks after the design materials are delivered.

1.2.2.2 Technical consulting and design **shall** be performed during two weeks at the contactor site.

1.2.2.3 On site design review **shall** be performed during one week in Korea.
(Exact location will be fixed later)

1.2.3 Selection process, payment and POC

1.2.3.1 Selection process

(D+0) RFP release → (D+7) Proposal submission → (D+15) Technical evaluation → (D+20) Cost evaluation → Selection

1.2.3.2 Payment

- 40% after contract
- 30% after Technical consulting and design
- 30% after On-site design review

1.2.3.3 Inquiries related with a proposal preparation may be asked or sent by mail to the following person.

Yongmin Jun, Ph.D.

Aeropropulsion Research Office
Korea Aerospace Research Institute
169-84 Gwahak-ro, Yuseong-Gu, Daejeon, Korea

ymjun@kari.re.kr
Tel) 82-42-860-2031 / Fax) 82-42-860-2626

1.3 Conditions for modification and cancellation of RFP

1.3.1 KARI reserves the right to change or modify the RFP if there is any change in the technical and business requirements of the RFP even after RFP issuance. Upon the incurred changes or modification of the RFP as above, the bidder shall submit the modified proposal in accordance with the specific instructions provided by KARI.

1.3.2 KARI reserves the right to withdraw this RFP at any time with a written notice to the bidder, in case of the proposal provided by the bidder does not meet the requirements of the RFP.

1.3.3 KARI reserves right to cancel the contract, if the contractor cannot get the approvals for the export license from the concerned governments within one month after the contract.

1.4 Preparation of the proposal

1.4.1 Proposal shall be prepared in English.

1.4.2 The basic unit shall be SI unit. British unit of power and weight could be used as a complementary unit. SI unit comes first and British unit shall be put in parentheses.

1.4.3 In order to substantiate a proposal, all relevant data shall be submitted as attachments. The proposal which is improvable or based on vague presumptions shall be excluded.

1.4.4 All electronic files including documentary evidences shall be prepared with MS-WORD and submitted by e-mail the address stated in Article 1.2.3.2.

1.4.5 Bidders shall obtain all required approvals for export license from the bidder's government.

1.4.6 In case of any changes herein including cancellation of the program, KARI will notify bidders individually.

1.4.7 Time and date in the RFP are specified by the Korean Standard Time (GMT+09:00) and Date.

1.4.8 The proposal and relevant documents provided by bidders will not be returned.

1.5 Notes for the preparation of Proposal

1.5.1 This proposal constitutes a firm and irrevocable offer. All prices **shall** remain valid until the final contract.

1.5.2 The negotiated price **shall** not exceed the price initially proposed except when KARI requires additional items during negotiation.

1.5.3 The bidder **shall** be responsible for all costs and expenses in preparation of its proposal and negotiation with KARI.

1.6 Authority of KARI

1.6.1 KARI reserves the right to reject proposals that are unrealistic or unreliable. KARI will not disclose the result of proposal evaluation.

1.6.2 In accordance with article 1.3.3, KARI reserves right to claim for compensation. The penalty will be double of the expenses which have been disbursed until the contractor pays the indemnity.

1.7 Maintenance of Secrecy

1.7.1 The bidders **shall** not disclose any part of this RFP without prior permission of KARI.

1.7.2 The bidders may not, in any manner, advertise or publish any matter in relation to the bidder's proposal.

2 Introduction

2.1 Preliminary mission profile

The target airframe is a tilt rotor UAS developed by KARI. The preliminary mission profile has been developed for the airframe. But it is welcome to use a helicopter mission.

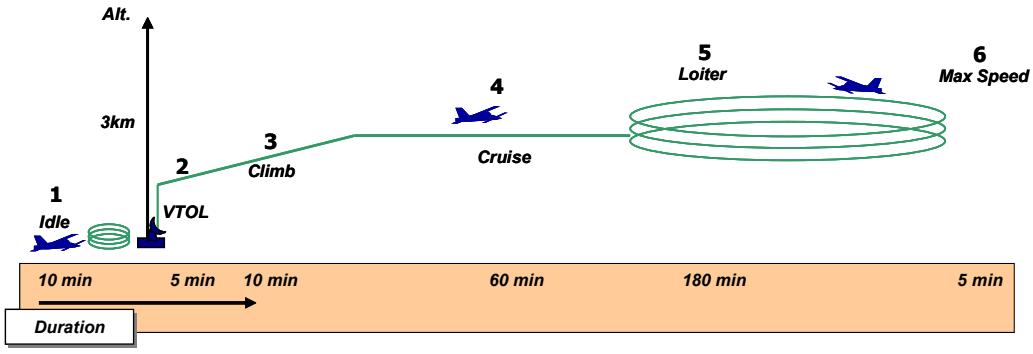

Figure 1 Preliminary mission profile

- Phase 1: Engine start, ground idle, and warm-up.
- Phase 2: Vertical takeoff in helicopter mode with 6,000rpm.
- Phase 2~3: Mode change from helicopter mode to forward flight mode with 6,000rpm. The minimum altitude for the mode change is above 300m.
- Phase 3: Climb in forward flight mode and accelerates to a climb speed to the cruising altitude (3 km).
- Phase 4: Cruise in flight mode at 3km.
- Phase 5: Loiter in flight mode at 3km.
- Phase 6: Maximum speed under half fuel weight condition. It accelerates up to Max speed at maximum continuous power.

- Phase 7: Return. Same as phase 4
- Phase 8: Mode change. Decelerates to a descent speed to the mode change altitude. Mode change from forward flight mode to helicopter mode with 6,000 rpm. The minimum mode change altitude is above 300m.
- Phase 9: Vertical landing in helicopter mode with 6,000 rpm.

2.2 Preliminary engine power requirement

2.2.1 Preliminary engine power requirement from the aircraft is shown in the Table 3

2.2.2 Engine reduction gearbaox will have 95% mechanical efficiency at design point

2.2.3 A 5kW generator pad will be designed as a part of the reduction gearbox.

2.2.4 Motor driven fuel pump and oil pump will be used as a part of engine accessary and they will consume 1kW electricity at most. This power should be provided by engine.

Table 3 Preliminary engine power ratings

	duration[min]	altitude[km]	Required power[hp]	Required power[kW]
Take off	5	SL~1	100	75
Climb	10	1~3	66	50
Cruise	60	3	73	55
Loiter	180	3	40	30

2.3 Configuration and performance requirements

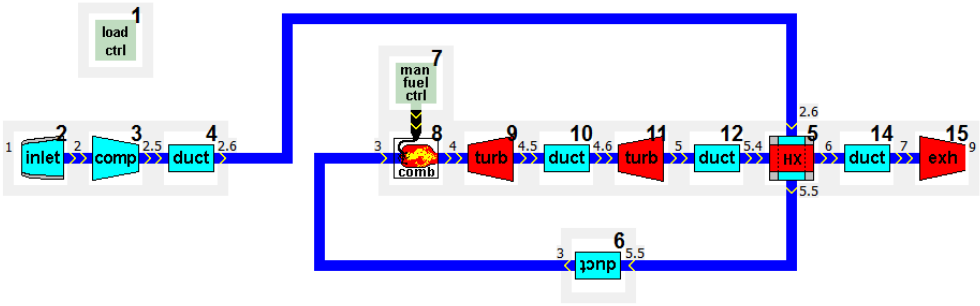

Figure 2 GSP model for the target engine

2.3.1 The target recuperated turboshaft has a gas generator (one stage centrifugal compressor & one stage radial turbine) and a free power turbine (one stage axial turbine) with a reverse type combustor.

2.3.2 Performances requirements

SFC ≤ 0.33 kg/kW-hr

Power to weight ratio ≥ 1.8kW/kg

2.4 Engineers background

2.4.1 Engineers who will participate in the Consultancy session have the following experiences.

- Years of altitude test of small turbofan/jet and turboshaft(T700)
- Engine cycle performance analysis for UAS
- Familiar with GasTurb & GSP and beginner to PROOSIS
- Engine operating SW development for a small turbofan engine

2.5 Tools

2.5.1 KARI has licenses of the following commercial tools

- GasTurb 11 (Preferred)
- GSP 11 (Preferred)
- PROOSIS

2.5.2 KARI engineers will bring their own tools for the Consultancy session.

3 Scope of work

3.1 General description

The goal of this technical consulting is to build up an engine design process, increase engineer's design capability, and review conceptual and preliminary design results. The consulting requires two sessions as below.

3.2 Remote design review

3.2.1 Review the conceptual design results

3.2.1.1 KARI will provide the conceptual design results which will include the followings.

3.2.1.1.1 Cycle design

- Design point & off design performance analysis

- Mission analysis

3.2.1.1.2 Component (turbomachinery) design results

- Compressor and turbine selections according to specific speed
- Defining design conditions, mean line design, performance analysis with empirical formulations
- Airfoil design based on flow path design

3.2.1.1.3 Component (burner) design results

- Design combustor sizing and injector configuration based on empirical data base.
- 1-D flow distribution and thermal analysis of the combustor by 1-D flow/thermal program

3.2.1.1.4 Engine 2-D layout design drawing

3.2.1.2 The design material will not more than 50 pages of MS power point and one(1) drawing.

3.2.1.3 Review **shall** be performed remotely and a review report **shall** be submitted.

3.2.1.4 KARI will send the review materials via DHL and the review report **shall** be submitted within two weeks after receiving the materials.

3.3 Technical consulting and design

In this session, a turboshaft engine design process is required to be built and a recuperated turboshaft engine, which has the target engine configuration and performance in article 2.3, is required to be designed and reviewed. Lectures, materials, comments, reviews, and discussions are required to accomplish this goal.

3.3.1 Review KARI's design result

3.3.1.1 KARI will provide the design results which include cycle design, components design, and engine layout design results. KARI will explain this design result on the first day of this session.

3.3.1.2 Review result **shall** be provided to KARI in MS WORD or MS Power Point format by the end of the session.

3.3.2 Engine design process buildup

3.3.2.1 Turboshaft engine design process, from requirement allocation to manufacturing, **shall** be documented, presented, and submitted to KARI by the end of the Consultancy session.

3.3.2.2 Turboshaft engine design standard and WBS for conceptual design and preliminary design phases **shall** be built based on engineering design process.

3.3.3 Lecture based engine design support and review

3.3.3.1 **Shall** lead a recuperated micro turboshaft engine design according to the design process, which will be built in this contract by article 3.2.2, and support and review KARI's design work.

3.3.3.2 The design **shall** meet the requirements in article 2.2 & 2.3.

3.3.3.3 Lecture based design leading, support and review **shall** be performed for KARI's design work during this session, while the lecture **shall** cover the key topics in 3.2.3.

3.3.3.4 Bidders **shall** propose a daily based plan to proceed this design work for this session.

3.3.3.5 During and at the end of this design work, design reviews **shall** be performed.

3.3.4 Key topics of engine design process.

3.3.4.1 The key topics of the target engine design **shall** be presented and discussed during the session.

3.3.4.2 Bidders **shall** propose scope of work which can be covered within the limited time, two weeks, based on the listed topics in article 3.3.4.4.

3.3.4.3 Bidders can propose other topics for engine design than the listed ones. In this case, bidders **shall** state rationales.

3.3.4.4 The topics of interest are as follows. The underlined topics are mandatory.

3.3.4.4.1 Cycle design

- The preliminary design process
- <u>Cycle selection and multi-design point methods</u>
- <u>Component multi-disciplinary design and sizing</u>
- <u>Common core / derivative engine</u>

3.3.4.4.2 Non-dimensional theory and performance modelling

- Use of non-dimensional theory for gas turbine modeling

- First and second order effects on non-dimensional method
- Limitations and compromises of non-dimensional parameters

3.3.4.4.3Real components and performance loss modelling

- Modelling uncertainty
- Intake, Compressor, Combustor, Turbine, Duct and nozzle, Heat exchanger, Gearbox, etc.

3.3.4.4.4Transient performance

- Starting behavior
- Transient behavior including accel & decal
- Dynamic modeling

3.3.4.4.5Engine rating and control

- System level requirement
- Performance requirement and implementation
- Modeling
- Fuel scheduling

3.3.4.4.6Diagnosis and deterioration

- Evaluation of performance differences
- Diagnosis

3.3.4.4.7Compliance and certification

- Validation to achieve Certification
- Compliance
- Validation of Status model

3.3.4.4.8Engine layout design

- Internal layout design
- Recuperator and gearbox installation

3.4 On site design review

In the Review session, a recuperated turboshaft engine design results **shall** be reviewed by documents, presentation, and discussion with KARI engineers.

3.4.1 Review engine design process

3.4.1.1 **Shall** check design process and design environments in KARI.

3.4.2 Review engine design results

3.4.2.1 A recuperated micro turboshaft engine conceptual and preliminary design results **shall** be reviewed.

3.4.2.2 Cycle design, components design, layout design results, and related analysis reports (areas of aerodynamic, structural, life, etc) **shall** be reviewed.

3.4.2.3 The Review session review report **shall** be submitted within two weeks after the Review session.

4 Other requirements

4.1 Meeting room

4.1.1 A meeting room **shall** be prepared for lecture and design work with a beam projector and a screen during the Consultancy session.

4.1.2 The meeting room **shall** be able to be occupied by KARI engineers by 6PM during the Technical consulting and design session.

4.1.3 The meeting room **shall** be equipped with beam project, and free WIFI.

4.2 Lecture materials

4.2.1 All lecture materials **shall** be provided in electric file format one week before the Technical consulting and design session.

4.2.2 Lecture materials **shall** be provided in hardcopy format for the Technical consulting and design session at the meeting room if they are not provided in electrical file format ahead.

5 Proposal Requirement

5.1 Contents of Proposal requirements

5.1.1 Proposal summary

5.1.2 Consultants

5.1.2.1 Consulting team summary

5.1.2.2 Consultants experiences (resume)

5.1.3 Proposal

5.1.3.1 Scope of lecture of key topics

5.1.3.2 A daily base plan to proceed a recuperated turboshaft engine design

5.2 Price proposal

5.2.1 Price **shall** be proposed in US dollar (Y2017).

5.2.2 Bidders **shall** include all cost items to cover the all activities in their proposals and itemize requested items. Lunch for trainees during the week in the Technical consulting and design session **shall** be included. Transportation, accommodation, and other items for the reviewer for the On-site review session **shall** be itemized and included.

5.2.3 The proposed price **shall** reflect possible fluctuations in labor costs, material prices and others in the proposed price. Therefore, the bidder **shall** not demand to reflect the fluctuation in cost due to cost items not stated in the bidder's proposal in the future.

6 Terms and Conditions

6.1 General terms and conditions

6.1.1 **Shall** follow KARI's terms and conditions

6.2 Intellectual property

6.2.1 All rights of design output produced in the Technical consulting and design session belongs to KARI.