

**Statement of Work (SOW) for
Fluid-Solid Interaction within the
Generalized Fluid System Simulation Program (GFSSP)
Dated, November 21, 2014**

NASA Launch Services Program (LSP)
Kennedy Space Center

Background

The GFSSP developed by NASA Marshall Space Flight Center (MSFC), is being utilized for propulsion and other fluids related problems; however, during a recent Return to Flight (RTF) activity, GFSSP was used to model a deployment system in which a pusher piston was activated and stroked to the end of its travel resulting in ringing of the system. Although this effort was performed by a member of the LSP Fluids team for a specific activity, and was performed with extensive use of GFSSP's user subroutines, it presented a new field for the development of GFSSP into a true multidisciplinary tool.

Objective

The purpose of this task/study is to perform a generalized proof of concept fluid-solid interaction capability within GFSSP to demonstrate over a broad array of problems the strength and capability of pursuing a more formal fluid-solid capability within the code. To this end, in Phase I of this effort the contractor shall work with the technical point of contact (POC) to identify up to a minimum of 6 distinct cases of fluid-solid interaction which shall be simulated via user subroutines. The contractor shall develop said GFSSP cases, with associated user subroutines, in a manner that can be generalized for Phase II. Phase II shall incorporate the generalized cases from Phase I into the main code (with help from both the technical point of contact (POC) and MSFC) in order to allow for general release to all users in the future. Phase III shall take the capability to a much higher level by coupling GFSSP to a solid/structural code such as ANSYS, etc.

Scope

The Contractor shall provide all labor and other resources unless otherwise noted to accomplish the work in this contract.

A. Base Task: Phase I - Proof of Concept

1. The contractor shall work with the technical POC to identify a minimum of six (6) or more distinct cases of interest for fluid-solid interaction to be modeled.
2. The contractor shall develop GFSSP models and corresponding user subroutines in order to perform the proof of concept demonstration of the fluid-solid interaction for the identified cases.

3. The contractor shall present the results of the modeled cases and any applicable comparisons with known solutions (closed form, empirical, etc.), if available, as a deliverable.
4. The contractor shall present an approach on the generalization of the identified cases for inclusion into the main GFSSP code as user options.
5. Deliverables:
 - a. Written monthly status reports
 - b. Midterm technical report
 - c. Midterm technical briefing
 - d. Final briefing
 - e. Final report that details the development and results of the test cases, user subroutines, etc., and provides the approach on the generalization of the cases for inclusion into the main code.
 - f. All models and coding developed.

6. Anticipated Project Milestones:	
Authorization to Proceed (ATP)	ATP
Midterm briefing	ATP + 6 mo.
Final briefing	ATP + 12 mo.

7. Travel	
Travel to KSC at ATP for kick off	ATP
Travel to KSC for midterm briefing	ATP + 6 mo.
Travel to KSC for final briefing	ATP + 12 mo.

B. Option 1: Phase II - Expansion of Cases and Incorporation of Cases into Main GFSSP Code

1. The contractor and the technical POC shall identify any additional distinct cases that shall be added in order to have a minimum of ten (10) distinct cases/options for users. The contractor shall develop the requisite models and generalized user subroutines for demonstration of fluid-solid interaction for the additional cases.
2. The contractor shall incorporate all of the cases identified in both the base task and this option into the main code. This shall include the execution of the approach for generalization of these cases from the base task.
3. The contractor shall present an approach on connecting GFSSP to one or more solid modeling codes such as ANSYS, NASTRAN, or Abacus.
4. Deliverables:
 - a. Written monthly activity reports
 - b. Midterm technical report

- c. Midterm technical briefing
- d. Final briefing
- e. Final report that details the development and results of the additional test cases, user subroutines, etc., a user's manual of the newly formed solid-fluid interaction options, and provides the approach on connecting/coupling GFSSP with a solid modeling code.
- f. All models and coding developed.

5. Anticipated Project Milestones:

- a. ATP ATP
- b. Midterm briefing ATP + 6 mo.
- c. Final briefing ATP + 12 mo.

6. Travel

- a. Travel to KSC at ATP for kick off ATP
- b. Travel to KSC for midterm briefing ATP + 6 mo.
- c. Travel to KSC for final briefing ATP + 12 mo.
- d. Travel to MSFC for final briefing encore ATP + 12 mo.

C. Option 2: Phase III - Coupling GFSSP with a Solid Modeling Code

1. The contractor shall develop a close coupled connection between GFSSP and one solid modeling code (ANSYS, etc.). The solid modeling code shall be determined by the technical POC at the start of this option based upon the solid modeling codes/tools available within LSP.
2. The contractor shall reproduce the identified test cases from Option 1 via the coupling of GFSSP and the solid modeling code.
3. The contractor and the technical POC shall identify a minimum of five (5) additional test cases for fluid-solid interaction that exploits the coupling of GFSSP and the solid modeling code. The contractor shall then develop and execute said cases.
4. Deliverables:
 - a. Written monthly activity reports
 - b. Midterm technical report
 - c. Midterm technical briefing
 - d. Final briefing
 - e. Final report that details the development and results code coupling including the aforementioned test cases, user subroutines, etc., and a user's manual for the coupled GFSSP/solid modeling code.
 - f. All models and coding developed.
5. Anticipated Project Milestones:

SOW for Fluid-Solid Interaction within the GFSSP

- | | |
|---|--------------|
| a. ATP | ATP |
| b. Midterm briefing | ATP + 6 mo. |
| c. Final briefing | ATP + 12 mo. |
| 6. Travel | |
| a. Travel to KSC at ATP for kick off | ATP |
| b. Travel to KSC for midterm briefing | ATP + 6 mo. |
| c. Travel to KSC for final briefing | ATP + 12 mo. |
| d. Travel to MSFC for final briefing encore | ATP + 12 mo. |

Other Direct Costs:

The contractor shall purchase, or utilize (if already obtained), a current copy of the solid modeling code in order to connect/couple GFSSP to said solid modeling code.

Technical Point of Contact:

Paul Schallhorn, Ph.D.
Chief, VA-H3
NASA LSP
KSC, FL 32899
(321) 867-1978 (v)
paul.a.schallhorn@nasa.gov