Amplifier Development in Support of the Atacama Large Millimeter Array Telescope

to

National Radio Astronomy Observatory
2015 Ivy Road, Suite 219
Charlottesville, VA 22903

JPL Task Plan No. 80-6827

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Prepared by:

Lorene Samoska
Task Manager

Prepared by:

Helen L. Tanabe
Senior Contract Administrator

Approved by:

For Diane Evans, Director for
Earth Science and Technology Directorate

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California 91109

EXECUTIVE SUMMARY

The newest telescope project of the National Radio Astronomy Observatory is the Atacama Large Millimeter Array (ALMA) Project. The telescopes will be making use of heterodyne receivers with local oscillators. The local oscillators require power amplifiers at millimeter wavelengths (60-200 GHz).

In this proposal effort, the Jet Propulsion Laboratory (JPL) will provide design, layout and testing support for the power amplifier development on the ALMA project. JPL has a long history in developing some of the world's fastest Monolithic Millimeter-wave Integrated Circuit (MMIC) amplifier chips which will benefit the needs of ALMA project.

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I. TECHNICAL SECTION

A. INTRODUCTION

The newest telescope project of the National Radio Astronomy Observatory (NRAO) is the Atacama Large Millimeter Array (ALMA) Project. This endeavor includes the collaboration of observatories from around the world in the manufacturing of 64 12-meter antennas. The telescopes will be making use of heterodyne receivers with local oscillators. The local oscillators require power amplifiers at millimeter wavelengths (60-200 GHz), as well as low noise amplifiers for the receiver front-ends. The telescope is expected to be the largest and most sensitive instrument in the world at millimeter and submillimeter wavelengths.

JPL will provide support in terms of the amplifier development for the local oscillators on the ALMA project. Our previous work for developing some of the world's fastest MMIC amplifier chips has overlapped with the needs of ALMA. In addition, JPL will design two (2) amplifiers based on NRAO's specifications, for use in HRL Laboratories' Indium Phosphide (InP) High Electron Mobility Transistor (HEMT) process foundry. The chips will be fabricated at HRL for NRAO, and then JPL will test the completed chips.

JPL'S SPECIAL COMPETENCIES

JPL has been a world leader in high frequency design and measurement technology, and has unique capabilities in the area of on-wafer monolithic millimeter-wave integrated circuit (MMIC) testing. In addition, JPL's experience with the Herschel/HIFI project has given us particular insight into high frequency (<100 GHz) power amplifier MMIC design and testing, and has resulted in the JPL-Submillimeter Wave Advanced Technology group's design of the world's fastest MMIC power amplifier to date.

B. OBJECTIVE

The objective of the proposed effort is to focus on development of 2 amplifier designs in the 60-200GHz range for the local oscillators on the ALMA project, as well as provide support on amplifier design, and layout issues for NRAO. JPL will perform the computer-aided design of the chips, perform the device layout, and test the chips, as well as NRAO designs, when they come back from fabrication. The chip testing would involve in-house JPL capabilities, such as on-wafer testing of S-parameters and on-wafer power measurements.

C. APPROACH

To meet the needs of NRAO, JPL proposes to design, fabricate and test the amplifier designs This effort will take place roughly over the course of one year. The design phase will be completed within the first 6 months of the contract start date and the testing phase will occur during the last 6-9 months. We estimate the role of personnel at JPL to last approximately 1 – 1.2 years.

D. MANAGEMENT PLAN

1. Task Management Responsibility

Lorene Samoska, the Principle JPL Investigator, will be responsible for the design and testing of the amplifiers. The proposed work would leverage from the various programs at JPL. This approach would maximize available resources to achieving the shared goal of obtaining high performance amplifiers for NRAO applications.

II. BUSINESS/COST SECTION

A. SCOPE OF WORK

JPL will, for National Radio Astronomy Observatory (NRAO), on a best-efforts, non-interference basis:

1. Perform two (2) amplifier designs and layout for 91-124 GHz and 120-144 GHz.
2. Provide support on design and layout issues for NRAO's own design efforts.
3. Upon fabrication of amplifier chips, perform on-wafer testing of the JPL designs as well as for the NRAO designs. The chips will be tested for S-parameters and on-wafer power measurements.
4. Prepare a quarterly Interim Technical Progress Report.
5. Prepare a follow-on task plan, if requested.
6. Prepare a final report.

B. DELIVERY SCHEDULE

JPL will deliver to NRAO, in JPL format:

1. 2 Amplifiers designs: 91-124 GHz and 120-144 GHz, due no later than 6 months after contract start date.
2. Test data for S-parameters and power of the two designs in item 1. above, as well as for NRAO's chip designs, due no later than 15 months after the contract date.
3. One copy of a quarterly Technical Progress Report, 4 months after contract start date.
4. One copy of a follow-on task plan, if requested, 12 months after the contract start date.
5. One copy of a final report, due no later than 15 months after contract start date.

National Radio Astronomy Observatory will deliver to JPL:

1. Funding in a timely manner.

Note: JPL's timely performance of this effort is contingent on the sponsor's delivery or review of the items stated above within the timeframe listed.

C. PERIOD OF PERFORMANCE

The period of performance for this task is from the date of execution of a task order amendment between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech) through 15 months.

D. CONTRACTUAL ARRANGEMENTS

1. General

The Jet Propulsion Laboratory (JPL) is a Federally Funded Research and Development Center (FFRDC), sponsored by NASA, that conducts programs in space science and other scientific areas specified or approved by NASA. The Jet Propulsion Laboratory is also an operating division of the California Institute of Technology (Caltech). Caltech is a private non-profit educational institution chartered under the laws of the State of California and is not an agent of the Government.

Under NASA Contract NAS7-1407, Caltech performs research and development tasks and operates JPL for NASA. The contract also allows a limited amount of research and development work to be performed for non-NASA sponsors (including other Government agencies and commercial entities). All work that NASA agrees to accept from non-NASA sponsors is on a reimbursable basis and is performed under Contract NA S7-1407. The work must be within the scope of work and terms and conditions of NAS7-1407, as determined by the NASA Contracting Officer.

Contract NAS71407 is a Cost Reimbursable Award Fee type contract. The costs to be charged for the proposed work must be consistent with contractual provisions and established procedures for costing under the current contract between NASA and Caltech (i.e., for work performed under the Contract, NASA provides JPL with the authority to incur costs and enables Caltech to receive reimbursements via drawdowns from a Letter of Credit.) JPL does not bill the Government for costs. JPL has no negotiated pricing or billing rates, and the non-NASA sponsor will be responsible for reimbursing NASA for the direct costs of the work performed together with applicable Allocated Direct Costs. Government audit is performed on a continuing basis by a Defense Contract Audit Agency resident team.

2. Funding

All reimbursable work shall be on an advance payment basis. The sponsor shall issue a check, a signed Cover Letter and/or Purchase Order (P.O.) directly to the NASA Contracting Officer listed below for Contract NAS7-1407. The check must be made payable to NASA. The check, Cover Letter and/or P.O. must acknowledge that the work to be performed shall be solely under the terms and conditions of NAS7-1407. The check, Cover Letter and/or P.O. shall be addressed to the NASA Contracting Officer for Contract NAS7-1407 as follows:

National Aeronautics and Space Administration
NASA Management Office-JPL
4800 Oak Grove Drive, Mail Stop 180-802
Pasadena, CA 91109

Attention: Mr. Angel A. Castillo, Contracting Officer

a. The CAGE code. If you do not have a CAGE Code, please refer to http://www.ccr2000.com/ to apply for one. If non-government sponsors are to conduct business with NASA (Government), they must have a CAGE Code.

b. The name, title, address, and telephone number of your proposed technical manager.

c. The name, title, address, and telephone number of the administrative point of contact for this effort.

d. A statement as to whether your organization has previously or plans to in the future solicit or accept proposals for substantially the same effort from private industrial, commercial or other profit-making organizations.

e. Reference the JPL Task Plan number and date.

NOTE: A signed original Attachment A shall be returned to the JPL Contract Administrator referenced on the JPL transmittal letter for this Task Plan.

3. NASA Acceptance

NASA will review all orders for acceptability under the contract; the processing time for reimbursable orders will be handled as expeditiously as possible. Upon receipt of NASA's placement of a Task Order, JPL is authorized to perform the effort agreed to between NASA and the sponsor.

4. Technical Direction and Monitoring

Sponsors will appoint an individual to provide technical direction and monitoring of the work performed as outlined in the Statement of Work provided in the Task Order. Overall contract administration responsibility continues to reside with the NASA Contracting Officer.

E. SPECIAL PROVISIONS

1. Publishing Work Results

JPL shall have the right to publish the results of its unclassified research for work conducted under this Task Plan. JPL shall provide copies of proposed publications to the sponsor no later than simultaneously with release for publication. JPL recognizes that such publication may impact on patentable inventions, and agrees to exert every reasonable effort to take appropriate patent actions prior to publication.

2. Accountability of Residual Property

It is intended that accountability for residual property purchased or developed in the performance of this effort shall reside with NASA.

Residual property is defined as any property not specifically identified as a deliverable in this Task Plan.

3. Accountability of Deliverable Property

As all work performed by JPL under any order or agreement entered into as a result of this task plan is subject to the provisions of Contract NAS7-1407 between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech), accountability of all deliverable property under such order or agreement must remain with NASA until final payment is made. On receipt of final payment and on the request of National Radio Astronomy Observatory, NASA will effect transfer of accountability of all such property to National Radio Astronomy Observatory.

4. Patent Statement

Proprietary Caltech/JPL Intellectual Property (New Technology Reports, Patents, or Copyrights), including NTR#20880, "A WIDE-BAND POWER AMPLIFIER WITH 9-13 DB GAIN FROM 85-146 GHz", may be used in the performance of the proposed work. Any commercial use of Caltech/JPL Intellectual Property must be negotiated with the Office of Technology Transfer at Caltech.

5. Miscellaneous Charges (dollars expressed in thousands)

		FY '02	FY '03	TOTAL
a.	AWARD Fee	$0.0	$0.0	$0.0
b.	DRDF (JPL's Director's Research & Development Fund Charge)	$0.0	$0.0	$0.0
c.	CAAS (NASA Contract Administration and Audit Services Charge)	$0.0	$0.0	$0.0
d.	Agency G&A (NASA General & Administrative Charge)	$2.8	$2.6	$5.4
Total AF/DRDF/CAAS/G&A		$2.8	$2.6	$5.4

a. AWARD FEE (AF) - The NASA/Caltech contract for the operation of the FFRDC is a cost plus award fee contract. As such, all sponsors placing funds on contract contribute a small percentage of task order dollars toward the award fee.

b. DRDF - NASA recognizes the importance of providing additional funding to the Director of JPL for the conduct of discretionary science and/or advanced technology research. Discretionary sponsored advanced research is generic in nature and benefits all sponsors of work at JPL. NASA provides several million dollars annually to fund its contribution to this discretionary research. In order to continue to promote the research in advanced technology and science, non-NASA sponsors also contribute a prorated share of this discretionary fund.

The Research and Development (R&D) program charge associated with this task will be applied to the related JPL advanced technology area of Exploratory Research & Concept Development. JPL will provide one copy of the Director's Research and Development Program Annual Report if requested.

Note: All efforts whose total estimated cost is $250,000 or greater will be subject to the Award Fee and DRDF charges as listed above.

c. CAAS - Actual NASA charges will be based on the total dollar value of the sponsor's reimbursable order based on the following schedule. Contract Administration and Audit Services (CAAS) for reimbursable orders over $1M are non-refundable.

Agreement Value*	Charge
$1M to less than $2M	$10k
$2M to less than $5M	$24k
$5M and over	0.52%

*Note: This is a non-refundable amount based upon the task plan Cost Estimate and will be charged on the initial order. If the total agreement value is increased, the CAAS charge will be recalculated and the customer charged accordingly.

d. Agency G&A - NASA Agency General and Administrative (G&A) rate applied to reimbursable sponsors.

6. INTELLECTUAL PROPERTY

The sponsor's rights to intellectual property are defined in Attachment A, the Intellectual Property Agreement with Caltech for work done under this Task Plan.

7. PROPRIETARY INFORMATION

The sponsor and JPL understand that, in the general course of the activities for this effort, neither party will offer the other information that is considered confidential or proprietary.

In the event that the sponsor desires to disclose confidential or proprietary information to JPL, (either written or oral), the sponsor will first inform JPL of the submission and explain the general nature of the proprietary information, to permit JPL to determine whether it wishes to receive said proprietary information. JPL agrees to hold such information that it agrees to receive in confidence for a period of three years from the receipt of the proprietary information provided that:

a. Written information has been appropriately identified by a proprietary legend; and

b. Oral disclosures of proprietary information are confirmed in writing within fifteen days by the sponsor to JPL, informing JPL of the subject matter to be held in confidence, when it was disclosed, and to whom.

c. JPL shall have no obligations regarding disclosure or use of any such information which (1) is already known to JPL, or (2) becomes publicly known through publication, inspection of product or otherwise and through no wrongful act of JPL, or (3) is received from a third party without a similar restriction and without breach of this Agreement, or (4) is shown by documentary evidence to have been independently developed by JPL, or (5) is disclosed to a third party by or on behalf of the sponsor (other than disclosure by the sponsor in connection with limited consumer testing) without a similar restriction on the third party's rights, or (6) is disclosed pursuant to the lawful requirement of a governmental agency or by order of a court of competent jurisdiction or disclosure as permitted by operation of law, provided that such disclosure is subject to all governmental or judicial protection available for like material and provided that before such

disclosure, the sponsor shall have been given prior written notice to JPL's intention to disclose and a reasonable opportunity to object to such disclosure.

d. In exceptional circumstances, JPL will hold proprietary information for a period of time longer than three years, provided that such period of time is agreed upon in writing by JPL prior to the sponsor disclosing such proprietary information to JPL. Current JPL procedures relative to treatment of proprietary information are included in Item 13. below.

8. TERMINATION

National Radio Astronomy Observatory may terminate this effort at any time by providing to the NASA Contracting Officer written notice of its decision to terminate. Costs associated with termination will be subject to reimbursement in accordance with the terms of NASA Contract NAS7-1407. Any funds remaining will be returned to National Radio Astronomy Observatory within a reasonable time after termination.

9. NO WARRANTY.

All deliverables provided to National Radio Astronomy Observatory pursuant to this Task Order are provided "AS-IS" without warranty, express or implied, as to any matter whatsoever, including, without limitation, the performance or condition of the research or any invention(s) or product(s), whether tangible, conceived, discovered, or developed under this Task Order; or the merchantability, or fitness for a particular purpose of the research or any such invention or product. The Government and the California Institute of Technology (Caltech) shall not be liable for any direct, consequential, or other damages suffered by Sponsor, any licensee, or any others resulting from the use of the research or any such invention or product.

10. INDEMNIFICATION

National Radio Astronomy Observatory agrees that it will be responsible to the Government and the California Institute of Technology (Caltech) for, and will indemnify and hold harmless the Government and Caltech, its trustees, officers, and employees, from any loss, cost, damage expense or liability, attorney's fees, or any suit therefore, by reason of actual or alleged damages or injury of whatsoever kind or character, arising out of or in connection with National Radio Astronomy Observatory alleged or actual negligent act or omission, regardless of whether such act or omission is active or passive.

11. EXPORT CONTROL OF TECHNICAL DATA

a. Any resulting agreement is subject in all respects to the laws and regulations of the United States of America, including (without limitation) the Export Administration Act of 1979 (50 U.S.C. App. 2401 et. Seq.), as amended, and the Arms Export Control Act (22 U.S.C. Section 2778), as amended, and all regulations thereunder.

b. The definition of "technical data" in the International Traffic in Arms Regulations cited in 22 Code of Federal Regulations, Section 120.10 in addition to the definitions of "software" and "technology" including all references thereunder, in the Export Administration Regulations cited in 15 Code of Federal Regulations, Section 772, shall apply as the definition of technical data for the purpose of this clause.

c. The definition of an "export" in the International Traffic in Arms Regulations cited in 22 Code of Federal Regulations, Section 120.17 and the Export Administration Regulations cited in 15 Code of Federal Regulations, Section 734.2(b) inclusive shall apply for the purpose of this task plan.

d. If at any time during the performance period of this task, the sponsor has reason to believe that technical data related to the task, and in JPL's possession, may need to be exported, it shall immediately notify JPL of such fact. In the event a license or other export approval is required, during the performance period of this task, for technical data related to the task and in JPL's possession, JPL shall apply for such a license or other export approval in a timely manner and diligently prosecute such application. The sponsor shall cooperate with JPL in connection with such application, including (without limitation) furnishing JPL or the appropriate U.S. government agency with such written assurances and other documents as may be required.

e. If, at any time after the sponsor has received technical data from JPL, it is determined that a license or other export approval is required for the sponsor to export such technical data, to a third party, either within or outside of the United States, the sponsor shall apply for such license or other export approval in a timely manner and diligently prosecute such application. The sponsor shall comply with any and all restrictions or conditions imposed by the terms of any export license or other export approval, upon its use or disposition of the technical data or product incorporating any such technical data, and further represents and warrants that any and all undertaking and statements made by it are and will remain true and correct.

12. EXPORT OF HARDWARE

a. Any resulting agreement is subject in all respects to the laws and regulations of the United States of America, including (without limitation) the Export Administration Act of 1979 (50 U.S.C. App. 2401 et. seq.), as amended, and the Arms Export Control Act (22 U.S.C. Section 2778), as amended, and all regulations thereunder.

b. The definition of "defense article" excluding "technical data" in the International Traffic in Arms Regulations cited in 22 Code of Federal Regulations, Section 120.10 shall apply jointly, with the definition of "commodity", in the Export Administration Regulations cited in 15 Code of Federal Regulations, Section 772 as the definition of hardware for the purpose of this clause.

c. The definition of an "export" in the International Traffic in Arms Regulations cited in 22 Code of Federal Regulations, Section 120.17 and the Export Administration Regulations cited in 15 Code of Federal Regulations, Section 734.2(b)(1) shall apply for the purpose of this task plan.

d. If at any time during the performance period of this task, the sponsor has reason to believe that hardware related to the task, and in JPL's possession, may need to be exported, it shall immediately notify JPL of such fact. In the event a license or other export approval is required, during the performance period of this task, for hardware related to the task and in JPL's possession, JPL shall apply for such a license or other export approval in a timely manner and diligently prosecute such application. Including (without limitation furnishing JPL or the appropriate U.S. government agency with such written assurances and other documents as may be required.

e. If at any time after the sponsor has received hardware from JPL, it is determined that a license or other export approval is required for the sponsor to export such hardware, to a third party, either within, or outside of the United States, the sponsor shall apply for such license or other export approval in a timely manner and diligently prosecute such application. The sponsor shall comply with any and all restrictions or conditions imposed by the terms of any export license or other export approval, upon its use or disposition of the hardware or product incorporating any such hardware, and further represents and warrants that any and all undertakings and statements made by it are and will remain true and correct.

13. PROCEDURES FOR NON-DISCLOSURE STATEMENTS

Signed Non-Disclosure Statements and Proprietary Documents received by JPL will be handled as follows:

a. A Non-Disclosure Agreement is to be signed before proprietary information is discussed. Any changes in or substitutions for these Non-Disclosure Agreements must be approved by Caltech General Counsel (Patent Office) before use.

b. Disclosure discussions relative to proprietary information should be attended by as few practicable. One key individual from JPL and one from each of the outside organizations in attendance of such a discussion will sign the Non-Disclosure Agreement binding the individuals and companies involved.

c. Approval from the JPL Earth Science and Technology Directorate must be provided by the Manager of the applicable Program Office or his/her designee.

d. The general nature and purpose of the discussion must be agreed upon by all parties before proprietary discussions are initiated.

e. Only those Proprietary documents deemed necessary for JPL to perform their technical and management functions will be retained at JPL.

f. Proprietary information and documents will be clearly marked as "Proprietary" and will be filed, closely monitored and controlled by a designated individual on the task team.

g. Copying of proprietary information without the permission of the sponsor will be prohibited.

F. COST ESTIMATE (dollars expressed in thousands)

		FY'02	FY'03	TOTAL
1.	Workyears	**.22**	**.21**	**.43**
2.	Total Direct Compensation (Includes Employee Benefits)	$24.7	$24.5	$49.2
3.	Travel	0.5	0.2	0.7
4.	JPL Services	4.5	2.5	7.0
5.	Procurements	2.0	1.0	3.0
6.	Multiple Program Support	4.3	4.5	8.8
7.	Total Direct Costs	36.0	32.7	68.7
8.	Allocated Direct Charge	11.1	10.9	22.0
9.	Total JPL Cost	47.1	43.6	90.7
10.	AF/DRDF/CAAS/G&A *See Special Provisions	2.8	2.6	5.4
11.	**Total Estimated Cost**	**$49.9**	**$46.2**	**$96.1**

ATTACHMENT A

INTELLECTUAL PROPERTY AGREEMENT WITH CALTECH
FOR JPL TASK PLAN No. 80-6827

The sponsor has agreed to fund, under the attached Task Plan, certain work to be done by Caltech pursuant to a NASA task order. This Intellectual Property Agreement is an exclusive Agreement between Caltech and National Radio Astronomy Observatory and does not imply that NASA is not a party to this Agreement.

Caltech, subject to terms and conditions of NASA Contract NAS7-1407 and other applicable pre-existing contract obligations, if any, agrees to grant the sponsor Intellectual Property rights for work done under this Task Plan as follows:

1. DISCLOSURE

Caltech will inform the sponsor of subject innovations, inventions and discoveries hereinafter collectively termed "Intellectual Property," made in the performance of tasks funded in part or in whole by the sponsor.

2. PATENTS

a. Filing

In the event that Caltech indicates in writing that it does not choose to file a patent application on Intellectual Property in a domestic or foreign country but the sponsor desires to have an application filed, Caltech shall file such an application upon the written request and at the expense of the sponsor and title to such Intellectual Property shall remain in Caltech. In such event, the sponsor shall pay Caltech all reasonable expenses for filing and prosecuting the patent applications filed at the sponsor's request and all expenses for maintaining the patents resulting therefrom. Where time permits, drafts of said applications will be sent to the sponsor and its comments considered. Where the sponsor pays all reasonable expenses for filing and prosecuting said patent applications and/or maintaining said patents resulting therefrom, then the sponsor and Caltech shall share equally in the income derived from licensing said patents to third parties, after the sponsor first deducts said expenses from any licensing income.

b. Non-Exclusive Licenses

For all Intellectual Property developed under tasks that are funded in part or in whole by the sponsor, the sponsor will receive upon request, at a minimum, a non-exclusive, royalty-free license. Except as provided elsewhere in this Agreement, licenses granted to other, non-funding, parties shall be on a royalty-bearing basis.

c. License Rights Greater than Non-exclusive

(i) This provision relates to individual tasks initiated under this Agreement where the sponsor believes that the acquisition of rights greater than a non-exclusive, royalty-free license to intellectual property is necessary to

the successful development and marketing of a product likely to emerge from such a task. In such event, upon application by the sponsor for greater license rights, prior to initiation of the task involved, Caltech shall consider whether under current Caltech policy, such greater rights are available to the sponsor and if so, to grant them on mutually agreeable terms and conditions. The sponsor reserves the right to withdraw the funding for said task if a satisfactory agreement relative to said greater rights cannot be reached beforehand.

(ii) Where not agreed upon in advance, for all subject inventions made in the performance of tasks funded in part or in whole by the sponsor, Caltech shall consider and, if appropriate under the current Caltech policy, to grant the sponsor greater license rights under mutually agreeable terms and conditions.

d. License to U. S. Government

The United States Government will receive a non-exclusive, non-transferable, royalty-free license for all Intellectual Property made in the performance of tasks.

3. COMMUNICATIONS

Communication between the sponsor and Caltech/JPL on Intellectual Property matters shall be addressed as follows:

Caltech:

Adam Cochran
Chief The Intellectual Property Counsel
California Institute of Technology
201-85 Central Engineering
Pasadena, CA 91125

National Radio Astronomy Observatory

_____
_____
_____
_____

4. This Agreement will be interpreted in accordance with the laws of the State of California.

5. IN WITNESS WHEREOF, the parties have caused the Intellectual Property Agreement to be duly executed and effective as of the date of signing by both parties.

California Institute of Technology

_____

By Date

_____

Print Name

_____

Title

National Radio Astronomy Observatory

_____

By Date

_____

Print Name

_____

Title