The following STATEMENTS OF WORK concern the cooperative HFGW Project with P. R. China and GravWave® LLC expected to commence in 2008 or 2009:

Purpose of Work: To develop designs, plans and specifications for instruments to detect and generate high-frequency gravitational waves (HFGWs) in the laboratory. The detector will be utilized for the basic-science purposes of sensing high-frequency relic gravitational waves (HFRGWs) having origin related to the big bang and for detecting the laboratory generated HFGWs. Use will be primarily made of "off-the-shelf" components and those components that are described in the open scientific literature and in various patents issued to Robert M L Baker, Jr (such as US Pat. Nos. 6417597B, 6784591B2, P. R. China Pat. Nos. 10055882.2, ZL 200510055882.2 and Patents Pending). Other components will be designed by the project participants during the design process.

DD1 HFGW Detector Development (Primarily Chinese Activity)

- **DD1.1 Design the titanium and stainless steel cryogenic containment vessel (approximately 2 meters in diameter and 3 meters in length), vacuum system (about 10-7 Torr) and cryogenic system refrigeration unit (temperature < 38 mK; possibly using a common Helium-Dilution Refrigerator) with the assistance of the *Shanghai Institute of Optics and Mechanics (SIOM).***

- **DD1.2 Design the power supply and recording apparatus with the assistance of the *Chongqing University* technical staff especially Professor Fangyu Li and Professor Yang Zhang, and Dr. Robert M L baker, Jr. of *Gravwave® LLC***

- **DD1.3 Design the microwave, 10 to 10,000 W, 4.9 to10 GHz transmitter of the Gaussian beam, to be focused on the central fractal membranes, with assistance of the *Chengdu Microwave Laboratory (CML)* especially Dr. Biao Li Chief of Microwave Antenna Division *Institute of Electronic Engineering of China Academy of Engineering Physics* and Vice Professor Jie Zhou Chief of Signal Processing Department *Southwest Institute of Electronic Engineering.***

- **DD1.4 Design the fractal membranes themselves with the assistance of the *Hong Kong University of Technology* especially Dr. Weijia Wen.**

  DD1.4.1 Design of the fractal membrane reflectors at waist of Gaussian beam including their paraboloidal form.
  DD1.4.2 Design of the fractal membranes on the containment vessel as part of the Faraday Cage.

- **DD1.5 Design of the microwave receivers (or perturbative photon-flux detectors) at each end of the receiver reasonce chambers, tunable around 4.9 to10 GHz, with assistance of the *Chengdu Microwave Laboratory (CML)* and the use of HEMT amplifiers or cQED detectors with the assistance of Gary Stephenson of *GravWave® LLC*. There will be three alternatives:**

  DD1.5.1 Off-the-shelf microwave horn plus HEMT detector/receiver.
  DD1.5.2 Rydberg-Cavity Detector as developed at *Kyoto University*.
  DD1.5.3 Circuit QED microwave detector developed at *Yale University*.

- **DD1.6 Design of the high-temperature superconductors chips and microwave-absorbent baffles**

DD1.6.1 Mosaic on the interior of the containment vessel (except for opening at the Gaussian-beam transmitter end) with the assistance of the *Chongqing University* technical staff under the direction of Professors Fangyu Li and Zhenyun Fang.

DD1.6.2 Interior baffles around Gaussian beam and "tunnel" between fractal-membrane reflectors and detectors under the direction of Dr. Robert M.L. Baker, Jr. of *GravWave® LLC.*

Following the completion of the detector development tasks, plans and specifications will be drawn up by the *Chongqing University* technical staff in cooperation with the *GravWave® LLC* team. These tasks parallel the development tasks. In the following Table **CC**: indicates Chongqing University China costs and **GT**: indicates the *GravWave® LLC* Team costs Please note that *GravWave ® LLC* holds 6 Patents and 14 Pending Patents in the Peoples Republic of China and the United States. for High-Frequency Gravitational Wave technology.

PROJECT DESIGN AND PLANS & SPECIFICATIONS TABLE FOR HFGW DETECTOR

Component	Design $	Design Months*	Plans & Specs $	Plans & Specs Months*
1.1 Containment Vessel	CC:9,000;GT:3,000	5	CC:6,000;GT:1,000	2
1.2 Test Apparatus	CC:12,000;GT6,000	6	CC:3,000:GT:1,000	2
1.3 Transmitter	CC:15,000:GT:5,000	7	CC:9,000;GT:3,000	4
1.4 Fractal Membranes	CC:15,000;GT:10,000	8	CC:12,000;GT:6,000	4
1.5 Receiver(s)	CC:18,000;GT:9,000	9	CC:12,000;GT:3,000	3
1.6 Refrigeration	CC:24,000;GT:6000	8	CC:15,000;GT:3,000	3
1.7 Magnet	CC:30,000;GT10,000	8	CC:18,000;GT:3,000	4
Total $	CC:123,000;GT:49,000		CC:75,000;GT:20,000	

* Many tasks can be done in parallel.

We will allow approximately 9 months for detector design and 4 months for the preparation of plans and specifications (**P&S**) with about a one month overlap, so a total of one year should be scheduled for the detector's design, plans and specifications. The following is the schedule for the Detector Tasks:

PROJECT DESIGN AND PLANS & SPECIFICATIONS SCHEDUEL FOR HFGW DETECTOR

Month > **Tasks**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
DD1.1		Δ	■	■	■	Δ						
P&S							Δ	Δ				
DD1.2	Δ	■	■	■	■	Δ						
P&S						Δ	Δ					
DD1.3		Δ	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ
DD1.4	Δ	■	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ
DD1.5	Δ	■	■	■	■	■	■	■	Δ			
P&S										Δ	■	Δ
DD1.6	Δ	■	■	■	■	■	■	Δ				
P&S										Δ	■	Δ
DD1.7	Δ	■	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ

Δ Start /Finish of Detector Task **Δ Start/Finish of Plans& Specifications (P&S)**

GD2 HFGW Generator Development (Chinese and *GravWave® LLC* Activity)

The HFGWs generated by the piezoelectric-crystal resonators (Film Bulk Acoustic Resonators or FBARs) would be the preferred method (discussed in "Piezoelectric-Crystal-Resonator High-Frequency Gravitational Wave Generation and Synchro-Resonance Detection," by Robert M. L. Baker, Jr., R. Clive Woods, and Fangyu Li, which after peer reviews, published in the *Proceedings of the Space Technology and Applications International Forum (STAIF-2006),* edited by M. S. El-Genk, American Institute of Physics, Melville, New York, Feb. 12-16, **813**, 2006, pp. 1280-1). As an alternative, to be held in abeyance and considered subsequently, we can utilize the laser HFGW generator (discussed in "Ultra-High-Intensity Lasers for Gravitational Wave Generation and Detection," by R.M.L. Baker, Jr., Fangyu Li and Ruxin Li, which after peer reviews, published in the *Proceedings of the Space Technology and Applications International Forum (STAIF-2006),* edited by M. S. El-Genk, American Institute of Physics, Melville, New York, Feb. 12-16, **813**, 2006, pp. 1249-1258). Both of these devices are based upon the novel formulation of the quadrupole equation by Baker (2006). As an augmentation of our current research activities we will pursue the FBAR-generator development Task GD2 with the following subtasks as suggested recently by Professor R. Clive Woods**,** Department Chairman, Department of Electrical and Computer Engineering, *Louisiana State University*.

- **GD2.1** Utilization plan for the Piezoelectric Resonators or FBARs that already exist (e.g., in every cell phone) and accomplish a modest design change to make the frequency coverage suitable for the magnetron drive (about 2.45 GHz) and make sure that the oscillation mode is optimized for the generation of HFGWs (2.45 GHz FBARs produce 2x2.45 = 4.9 GHz HFGWs). Designed by

Professor R. Clive Woods, Department Chair Electrical and Computer Engineering, *Louisiana State University* and *GravWave® LLC* and the *Chengdu Microwave Laboratory (CML).*

- **GD2.2** Develop survey and site plan, approximately 20 km in length, for positioning the parallel-track, Magnetron/FBAR linear-array elements to an accuracy of 1/10th wavelength or ± 0.6 mm. Accomplished by the *Chongqing University* technical staff under the direction of Professor Fangyu Li and Zhenyun Fang with Gary Stephenson of *GravWave® LLC.*

- **GD2.3** Design suitable magnetron power supplies – including a 10-20 Megawatt Power Station. Designed - under the direction of Professor R. Clive Woods, Department Chair Electrical and Computer Engineering, *Louisiana State University* and *GravWave® LLC* and with the assistance of Gary Stephenson and Dr. Robert M L Baker, Jr. of *GravWave® LLC* and the *Shanghai Institute of Optics and Mechanics (SIOM)* especially Dr. Ruxin Li.

- **GD2.4** Design of phased linear-array feeds from magnetrons to piezoelectric resonators – all resonators must oscillate exactly in phase as the gravitational wave passes them at the speed of light along the two linear-array tracks. Designed by Professor R. Clive Woods, Department Chair Electrical and Computer Engineering, *Louisiana State University* and *GravWave® LLC* and the *Chengdu Microwave Laboratory (CML)* especially Dr. Zhou and Dr. Chuan-Ming Zhang.

- **GD2.5** Develop a construction plan for the two linear array tracks of magnetrons and FBARs with the assistance of the *Chongqing University* technical staff under the direction of Professor Fangyu Li and Zhenyun Fang and Dr. Robert M L Baker, Jr. of *GravWave® LLC.*.
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- **GD2.6** Design of the phase-locking process for the magnetrons as presented in GD2.4. with the assistance of the *Chengdu Microwave Laboratory (CML)* especially Dr. Zhou and Dr. Chuan-Ming Zhang and Professor R. Clive Woods, Department Chair Electrical and Computer Engineering, *Louisiana State University* and *GravWave® LLC*.

- **GD2.7** Develop a plan, using known technology and methods, for constructing and testing HFGW superconductor optics – if not an essential, then a highly advantageous part of any HFGW generator/detector (or relic detector) system. Designed by Professor R. Clive Woods, Department Chair Electrical and Computer Engineering, *Louisiana State University* and *GravWave® LLC* and with the assistance of the *Shanghai Institute of Optics and Mechanics (SIOM)* .

As in the case of the first Table **CC**: indicates Chongqing University China costs and **GT**: indicates GRAVWAVE Team costs. Both **CC** and **GT** costs would have to come from Chinese sources since **no US funds for HFGW research are available**. As mentioned previously, *GravWave® LLC* holds 6 Patents and 14 Pending Patents in the Peoples Republic of China and the United States for High-Frequency Gravitational Wave technology.

PROJECT DESIGN AND PLANS & SPECIFICATIONS TABLE FOR HFGW GENERATOR

Component	Design $	Design Months*	Plans & Specs $	Plans & Specs Months*
2.1 Piezoelectric Resonators	CC:9,000;GT:12,000	4	CC:6,000;GT:6,000	2
2.2 Survey Plan	CC:12,000;GT:4,000	6	CC:9,000;GT:3,000	3
2.3 Power Supplies	CC:12,000;GT:6,000	7	CC:12,000;GT6,000	4
2.4 Phased-Array Feeds	CC:15,000GT:10,000	8	CC:12,000; GT:9,000	4
2.5 Cluster/Array Construction Plan	CC:18,000GT:36,000CC:	8	CC:12,000; GT:24,000	4
2.6 Magnetron Phase Locking	CC:24,000;GT:48,000	9	CC:15,000; GT:15,000	3
2.7 Superconductor Optics	CC:30,000;GT:50,000	8	CC:18,000; GT:20,000	4
Total $	CC:111,000; GT:166,000		CC:78,000; GT:83,000	

* Many tasks can be done in parallel.

We will allow about 9 months for generator design and 4 months for the preparation of plans and specifications (**P&S**) with about a one month overlap so a total of one year should be scheduled for the generator's design, plans and specifications. The HFGW generator Tasks could be accomplished in parallel with the HFGW detector Tasks or they could follow the detector Tasks. The following is the Task Schedule for the Generator:

PROJECT DESIGN AND PLANS & SPECIFICATIONS SCHEDUEL FOR HFGW GENERATOR

Month > **Tasks**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
GD2.1	Δ	■	■	Δ								
P&S					Δ	Δ						
GD2.2	Δ	■	■	■	■	Δ						
P&S						Δ	■	Δ				
GD2.3		Δ	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ

GD2.4	Δ	■	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ
GD2.5	Δ	■	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ
GD2.6	Δ	■	■	■	■	■	■	■	Δ			
P&S										Δ	■	Δ
GD2.7	Δ	■	■	■	■	■	■	Δ				
P&S									Δ	■	■	Δ
GD2.8				Δ	■	■	■	■	Δ			
P&S										Δ	■	Δ

Δ Start /Finish of Generator Task Δ Start/Finish of Plans& Specifications (P&S)

VSA3 Very Speculative Applications of HFGWs

The following list of very speculative applications of HFGWs involves the name of the key champion or advocate of the application, a brief discussion of it and one or more peer-reviewed publications in the open scientific literature related to it (many of these publications represent the fruits of the current Chinese and *GravWave® LLC* Joint HFGW Project). These potential practical applications of HFGWs (applied research) may well turn out to be the principal driving force for the pursuit of HFGW basic research; even though the theoretical basis for them must await the successful completion of our HFGW generation and detection experiment

VSA3.1 Telecommunications

Championed by Gary Stephenson of *Boeing*, El Segundo, California, USA.

Multi-channel communications (both point to point, for example to deeply submerged submarines, and point to multipoint – like cell phones-- through all ordinary material things – the ultimate wireless system). One could communicate directly through the Earth from New York in the United States to Beijing in China, without the need for fiber optic cables, microwave relays, or satellite transponders – antennas, cables, and phone lines would be things of the past! Even the timing afforded by HFGW stations around the globe could result in at least a **50 Billion dollar** savings in conventional telecom systems over ten years according to a recent analysis of Harper and Stephenson. Essentially it would allow for greater telecommunications bandwidth usage efficiencies by synchronizing, through the use of HFGWs (which, unlike electromagnetic waves, move at constant speed through the Earth and atmosphere) all telecom transmitters and receivers. Thus no communication time would be needed for "waiting" for messages to appear – one message could follow right after another since you know precisely (to nanoseconds or better) when they will come in. Specifically, Harper and Stephenson find cost savings in communications message search-space and frequency-reference improvement and phase-noise reduction. Each savings is small, but their analyses show that Billions of dollars in telecommunications costs could be saved.

"The Value Estimation of an HFGW Frequency Time Standard for Telecommunications Network Optimization," by Colby Harper and Gary Stephenson. After peer reviews, published in the *Proceedings of the Space Technology and Applications International Forum (STAIF-2007)*, edited by M. S. El-Genk, American Institute of Physics, Melville, New York **880**, pp. 1083-1091, Feb. 12-15, 2007. Please see www.GravWave.com , RECENT PUBLICATIONS, 4.) AIP; HFGW Telecommunications.

VSA3.2 Optics

Championed by R. Clive Woods, Department Chairman, Department of Electrical and Computer Engineering, *Louisiana State University*, USA.

In theory a superconductor exhibits a large index of refraction for HFGWs. Thus optical devices, such as astronomical telescopes (both refracting and reflecting), communication-link concentrators, variable-focus HFGW optical systems can be designed and utilized in practice.

United States Patent Number 6,784,591 B2, "Gravitational Wave Generator Utilizing Submicroscopic Energizable Elements," Robert M. L. Baker, Jr., filed July 14, 2000.

"An Experimental Program for Assessing High-Frequency Gravitational Wave (HFGW) Optical Applications and the Precursor HFGW Telescope," by Robert M. L. Baker, Jr., after peer reviews, published in the proceedings of the *Space Technology and Applications International Forum (STAIF-2004)*, edited by M. S. El-Genk, American Institute of Physics, Melville, New York, February 8-12, 2004, **699**.

"Manipulation of Gravitational Waves for Communications Applications using Superconductors," by R. Clive Woods. *Physica C* **433,** pp. 101-107 , 2005.

"A Novel Variable-Focus Lens for HFGWs," by R. Clive Woods, after peer reviews, published in the proceedings of *Space Technology and Applications International Forum (STAIF-2006)*, edited by M.S. El-Genk, American Institute of Physics Conference Proceedings, Melville NY **813,** pp. 1297-1304., February 12, 2006.

"Modified Design of Novel Variable Focus Lens for VHFGW,**"** by R. Clive Woods, after peer review published in the proceedings of *Space Technology and Applications International Forum (STAIF-2007)*, edited by M.S. El-Genk, American Institute of Physics Conference Proceedings, Melville, NY **880**, pp. 1011-1018., February 14, 2007.

VA3.3 Surveillance

Championed by Robert M. L. Baker, Jr. of *GravWave® LLC*, Playa del Rey, California, USA.

The potential for through-earth, or through-water "X-rays" utilizing the extreme sensitivity of HFGW generation-detection systems to polarization angle changes (possibly less than 10^{-40} radians or one Billion, Billion, Billion, Billionth of a degree) in order to observe subterranean structures, geological formations (such as oil deposits), create a transparent ocean, view three-dimensional building interiors, buried devices, hidden missiles, weapons of mass destruction, achieve remote acoustical surveillance or eavesdropping, etc. – a full-body scan without radiation danger.

"Surveillance Applications of High-Frequency Gravitational Waves**,"** by Robert M.L. Baker, Jr, after peer review published in the proceedings of. the *Space Technology and Applications International Forum (STAIF-2007)*, edited by M.S. El-Genk, American Institute of Physics Conference Proceedings, Melville, NY **880**, pp. 1017-1026, February 15, 2007. Please see www.GravWave.com, RECENT PUBLICATIONS, 6.) AIP; Surveillance.

VSA3.4 Propulsion

Championed by Eric Davis, of the *Institute for Advanced Studies at Austin*, Texas, USA and Giorgio Fontana, Professor, *University of Trento,* Italy.

As discussed in the authoritative text by Landau and Lifshitz, (1975), on page 349 of their fundamental (and internationally recognized authority on gravitational radiation) treatise, they state: "**Since it has definite energy, the gravitational wave is itself the source of some additional gravitational field... its field is a second-order effect ... But *in the case of high-frequency gravitational waves the effect is significantly strengthened...***" Thus it is possible to change the gravitational field near an object by means of HFGW and **move or perturb it**. Thus HFGWs provide a remote means for causing perturbations to the motion of objects such as missiles (anything from bullets to ICBMs), spacecraft, rogue comets or minor planets that are destined to impact Earth, land or water vehicles or craft – **a totally new propulsion system!**

"Gravitational Wave Propulsion," by Giorgio Fontana, after peer review accepted for publication in the proceedings of the *Space Technology and Applications International Forum (STAIF-2005),* edited by M. S. El-Genk, American Institute of Physics, Melville, New York, **699**, February 14, 2006.

VSA3.5 Nuclear Fusion

Championed by Giorgio Fontana, Professor, *University of Trento,* Italy.

If there is an ultra high intensity HFGW flux impinging on a nucleus, then it is possible to initiate nuclear fusion at a remote location – mass disruption. Also it may be possible to create radioactive waste-free nuclear reactions and energy creation.

"HFGW-Induced Nuclear Fusion**,"** by Giorgio Fontana and Robert M. L. Baker, Jr., after peer review published in the proceedings of *Space Technology and Applications International Forum (STAIF-2007),* edited by M.S. El-Genk, American Institute of Physics Conference Proceedings, Melville, NY **880**, pp. 1156-1164, February 16, 2007. Please see www.GravWave.com, RECENT PUBLICATIONS, 6.) AIP; Nuclear Fusion.