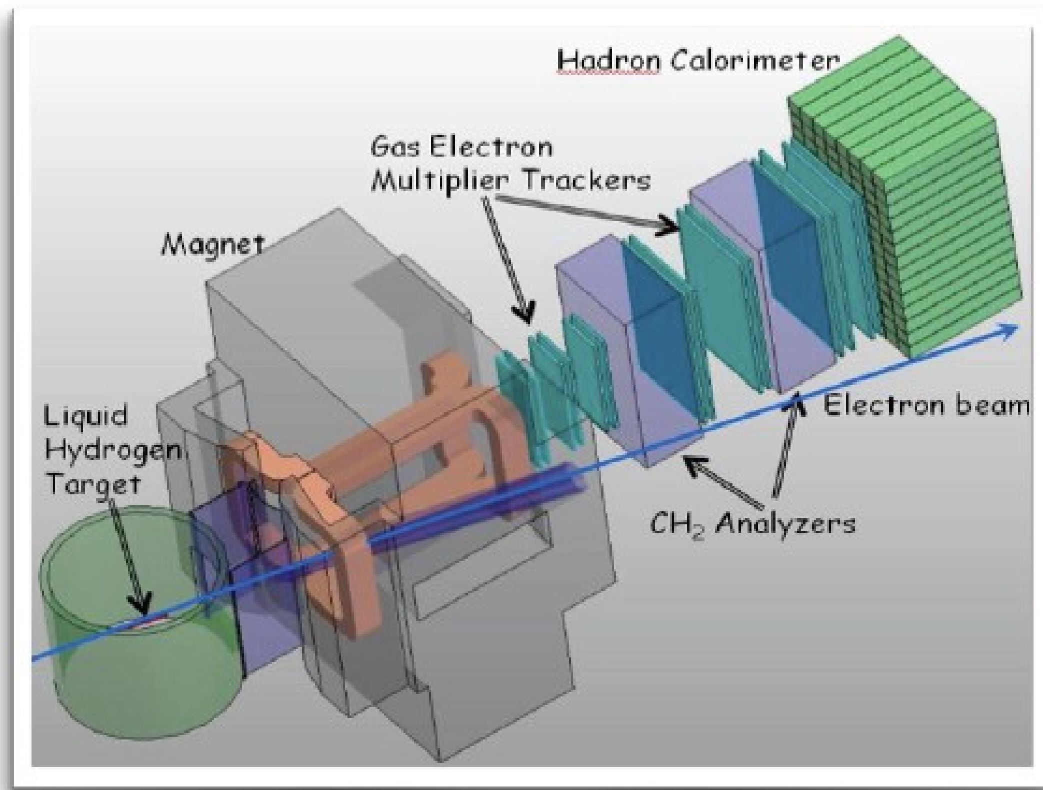
Super-BigBite-Spectrometer (SBS)

Program Management Plan



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Approval

Submitted By:

Project Manager	Date
Hall A Leader	Date
Associate Director for Experimental Physics	Date
	Date

Approved By:

Thomas Jefferson National Accelerator Facility Director	Date

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Change Log

Rev. No.	Date	Change Description	Pages Modified
0		New Issue	N/A

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List of Acronyms

CCB	Change Control Board
CDR	Conceptual Design Report
CEBAF	Continuous Electron Beam Accelerator Facility
CR	Change Request
DOE	Department of Energy
DOE HQ	Department of Energy Headquarters
ES&H	Environment, Safety & Health
FY	Fiscal Year
GEM	Gas Electron Multiplier
GeV	Giga electron Volts
ISM	Integrated Safety Management
KPP	Key Performance Parameters
JSA	Jefferson Science Associates
PCSM	Project Control System Manual
PED	Preliminary Engineering and Design
PMP	Program Management Plan
PM&IP	Project Management & Integrated Planning
PM	Project Manager
QA	Quality Assurance
SBS	Super BigBite Spectrometer
SC	Office of Science
TEC	Total Estimated Costs
TJNAF	Thomas Jefferson National Accelerator Facility
TJSO	Thomas Jefferson Site Office
TPC	Total Project Costs
WBS	Work Breakdown Structure

1. Introduction

Background Information and Program Description

This Super Bigbite Spectrometer (SBS) program management plan describes the strategy Jefferson Lab and its collaborative partners will use to produce the research equipment required to conduct a series of elastic nucleon electromagnetic form factor measurements.
Each of the measurements will use the electron beam from the upgraded 12-GeV CEBAF accelerator. The three experiments include:

- A measurement of G_E^n/G_M^n to Q^2=10 GeV^2 using the double polarization beam-target technique.
- A measurement of G_E^p/G_M^p to Q^2=12 GeV^2 using the double polarization beam-recoil-polarimeter technique.
- A measurement of G_M^n/G_M^p to Q^2=13.5 GeV^2 by determining the cross-section ratio for the two reactions d(e, e'n) and d(e, e'p)

These experiments will determine all four elastic electromagnetic nucleon form factors, as well as making possible a flavor separation. Because all the elastic form factors drop off so quickly at high values of Q^2, the three experiments will all depend critically on both high luminosity as well as relatively large acceptance.

The three measurements each require a somewhat different experimental setup, they are designed so that they can be accomplished using largely common components that can be rearranged into the required configurations. Collectively, this set of components is called the "Super Bigbite Spectrometer." The project will take advantage of the equipment associated with the existing BigBite spectrometer that resides in Jefferson Lab's experimental Hall A.

The SBS focuses on large-acceptance detection, makes use of an existing magnet, and will utilize a detector package with state-of-the art Gas Electron Multiplier (GEM) tracking detectors. GEM technology has advanced significantly in recent years. Collaboration with INFN-Rome has already begun development of the front-end GEM's and data acquisition electronics such that the final design is essentially already in-hand.

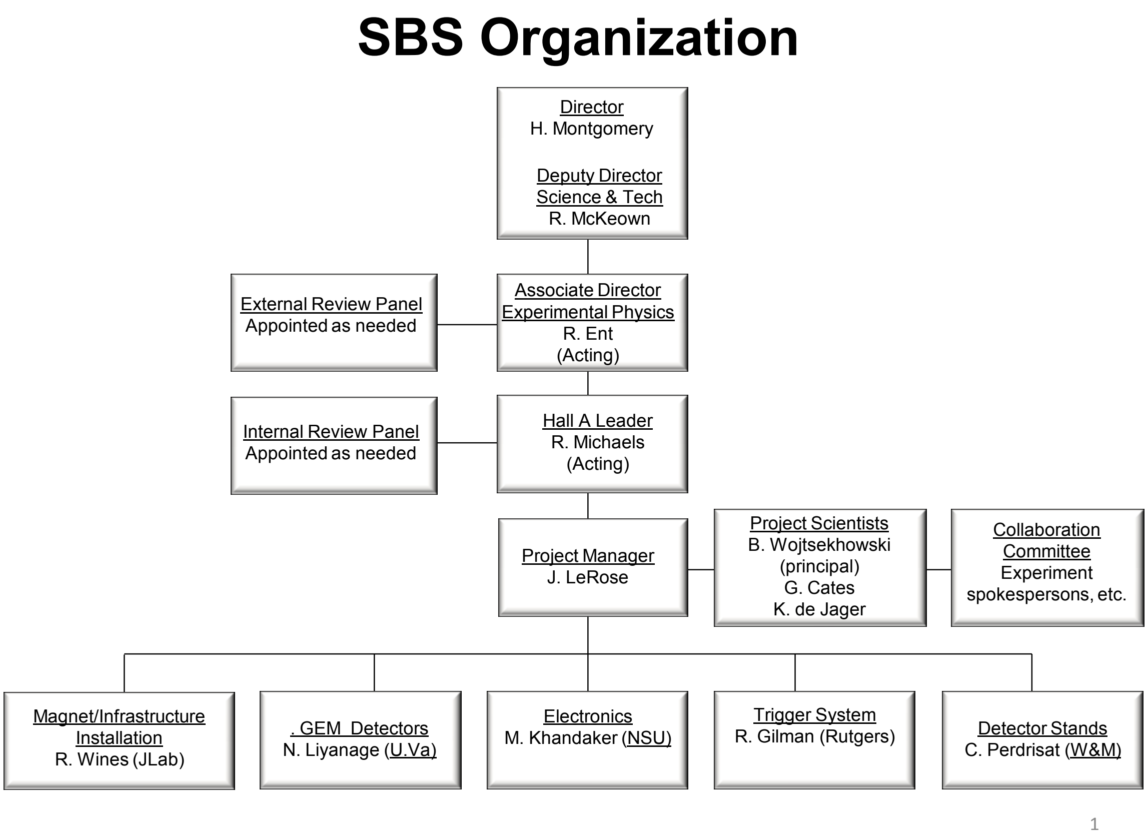
A separate Research Management Plan document is being developed to describe the plans of a group of institutions within the Electro Magnetic Form Factor (EMFF) collaboration for the management of the SBS research pursuits connected. Research efforts coupled with the SBS program include simulations of the detector performance, development and execution of calibration procedures for the detector, commissioning of the detector, development of analysis software, physics analysis and operation of the detector.

Program Approach

The SBS program will consist of three separate, but highly interrelated projects. The first project, **SBS Basic**, involves the acquisition of the magnet and the associated work of preparing it for use in SBS. The effort includes modifications to the magnet, the design and development of the infrastructure needed to run the magnet, and the construction of the platform on which it will stand. The second project, **Neutron Form Factor**, involves the development of a sufficient number of GEM detectors required to perform the approved neutron form factor measurements. The third and final project, **Proton Form Factor**, involves the construction of the full complement of GEM detectors as well as the installation of exit field clamps and pole shims as needed for the approved proton form factor measurements. The field clamps will require the addition of a solenoid to minimize the magnetic field on the beamline.

2. Program Organization

The SBS program is a joint collaboration between Jefferson Lab, University of Virginia, Norfolk State University, Rutgers University, and the College of William and Mary. Jefferson Lab will establish contractual agreements between itself and each university. A clear definition of the roles and responsibilities that individuals and their organizations play will be critical to the success of the three SBS projects. Jefferson Lab will be the lead integrator in pulling the various equipment items together to assemble the SBS apparatus. The universities are responsible for producing the deliverables identified below.



3. Program Assumptions, Constraints and Dependencies

Assumptions

In order to actually do the proposed measurements in the phased approach described, other things besides the SBS itself will have to be developed. Most notably the JLab 12 GeV Upgrade will have to be completed, but also various other Hall A systems will be required as well in order to perform the measurements. These include the Polarized ^{3}He target, the Hadron Calorimeter, etc. Some already exist, but nevertheless will require some effort to have them appropriately operational for these specific measurements.

Constraints

Completion of the experiments defined in the project will require the successful completion of the JLab 12 GeV Upgrade. If the 12 GeV upgrade should be significantly delayed the timescale for this program could be stretched accordingly.

Dependencies

The anticipated measurements will require the development of the “Hadron Calorimeter”, a separate project pursued by Carnegie-Mellon University. The ongoing development of a Polarized ^{3}He target at the University of Virginia is expected to continue as well.

4. Program Risk Management Approach

The SBS program team will employ a disciplined risk management process to forecast and manage risks before they become serious issues. The objective of this process is to proactively identify and manage project related risks throughout the project's life cycle.

- The SBS program team will conduct risk planning to develop and document an organized, comprehensive, and interactive strategy and methods for managing project risk.
- The SBS program team will conduct a risk identification process by examining the project areas and critical technical processes to identify and document associated risk events.
- The SBS program team will conduct risk analyses of each identified risk area or process to refine the description of the risk, isolate the cause, and determine the effects.
- The SBS program team will implement a risk handling process that will identify, evaluate, select, and implement options in order to set risk at acceptable levels given project constraints and objectives.
- The SBS program team will implement a risk mitigation process that will describe the actions taken to control an identified risk event by risk reduction, transfer, or elimination.
- The SBS program team will implement a risk monitoring process that systematically tracks and evaluates the performance of risk-handling actions against established metrics throughout the acquisition process and develops further risk-handling options, as appropriate.

Through risk analysis, adequate schedule and budget contingency will be established to ensure successful completion of the project within the desired objectives.

5. Program Change Control

Once a project baseline has been established and approved, a formal baseline change control process will be implemented. The SBS project will follow a modification of the process outlined in the JSA Project Control System Manual (PCSM).

- The SBS project team will modify the PCSM Change Request form to suit project needs.
- The SBS project team will use the PCSM Change Request Log to summarize and status the project Change Requests.
- The SBS project team will establish a Change Control Board to evaluate proposed Level 1 (see Table below) changes to the project baseline. Membership of the CCB will consist of the JLab Associate Director of Experimental Physics, Project Manager, Project Scientists, and representatives of participating University groups.

Change Control approval levels will be handled in accordance with the table below:

Project Change Control Approval Authority		
	Level 1 JLab Associate Director of Experimental Physics	**Level 2 Project Manager**
Scope/Technical	Any change that affects the products identified in PMP Project Deliverables table	NA
Schedule	Any change to a Level 2 Milestone greater than 3 months or to a Level 1 Milestone	Any change to a Level 2 Milestone less than 3 months
Cost	Any change greater than $100K or that requires the use of contingency	Any change less than or equal to $100K that does not use contingency.

6. Program Environment, Safety, Health, & Quality

All phases of the SBS project will be carried out in accordance with the Jefferson Lab Environment, Health and Safety (EH&S) policies and procedures as documented in the Jefferson Lab "EH&S Manual" including obeying all local, state and federal regulations. The laboratory has as one of its guiding principles, the protection of the health and safety of its employees, contractors and the public. The environmental, safety, and health risks/issues are considered small and manageable within current standard processes.

SBS project work will be conducted under the laboratory's existing Integrated Safety Management (ISM) Program. ISM is an integral part of Jefferson Lab's management structure spelled out in detail in the "EH&S Manual", the "Quality Assurance Manual", and various management manuals and training documents. Particular attention and planning will be given to those items which have the greatest potential to impact the project cost, schedule, and performance. Extensive testing and evaluation will be carried out for all of the critical components whether purchased or fabricated and assembled in house. Proposed project work will be performed under the standards and codes set forth in the TJNAF DOE JSA contract, Federal Occupational Safety and Health Act (OSHA), 29 Code of Federal Regulations (CFR) 1926, 10 CFR851, and Virginia OSHA as supplemented by Jefferson Lab work rules.

The Physics Division at JLab requires all "major installation experiments" to undergo and pass a "Readiness Review" before they are allowed to proceed. The "Readiness Review" focuses on the actual technical readiness of all the experiment's components and their safe operation. The experiments to be performed in this program will all be required to undergo such a review.

Training

Principal players are Ph.D. Physicists, their students, Engineers, and qualified technicians. No additional training beyond what is already required to work safely and effectively at their respective institutions is required. Naturally, all work done at JLab will be done in accordance with the procedures and training requirements spelled out in the JLab EH&S manual. Work done at the Universities will be done in compliance with the rules and procedures spelled out at each Institution.

7. Program Communications

Project communications must be proactive and timely, responding to accomplishments and emerging issues or activities. Communications will focus on disseminating information regarding project objectives, strategies, problems/issues, and status. Due to the collaboration needs of the SBS project, use of phone calls and e-mails will be the central mode of communication among project participants. Meetings can be arranged as needed with phone, Skype, or EVO connections available for those off-site.

Project Reviews

Progress on the magnets, platforms, beamline, detectors and electronics will be monitored by the project manager. In the event of a serious problem, e.g., a detector performance issue, an appropriate review would be called and proposed changes to overcome the problem would be evaluated.

Collaboration meetings will be held regularly to keep collaborators informed of progress and problems.

The experiments themselves will be subject to the JLab Physics Division Readiness Review Process as described above in “Program Environment, Safety, Health, & Quality”.

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8. The SBS Basic Project

a. Project Scope

WBS and Dictionary

WBS 1.	SBS Basic Project	This WBS element includes the general setup in the experimental Hall A, the modification of the magnet with its power supply, and the design and construction of the basic beamline and platform.	**1.1**	Hall A Infrastructure	**1.1.1**	Magnet
					1.1.2	Platform
					1.1.3	Beamline

The SBS spectrometer itself is a large dipole made from a modified 48D48 magnet obtained from Brookhaven National Laboratory (bnl) for the cost of disassembling and moving it. The modifications include:

- Machining a slot in the return yoke to allow passage of the beam at small scattering angles
- New coils to accommodate the new geometry
- Field clamp to reduce the field at the target
- Providing a small solenoid to minimize the magnetic field in the beam slot around the field clamp

The magnet will require a support structure to hold it and the detectors behind it. The magnet will also require a power supply with all necessary infrastructure to power the magnet (water, AC power, busses, etc.)

b. Project Deliverables

Jefferson Lab will produce the deliverables for the SBS Basic project:

- Magnet transportation and modifications
- Beamline and magnets
- Magnet power infrastructure
- Magnet platform
- Electronics hut
- Lead tube platform

c. Key Performance Parameters

- Modified Magnet must be in its final position on the platform must be energized and produce an integrated magnetic field in the gap of >1.8 T-m with field gradient at the target <200 m-g/cm
- Shielding as required must be in place
- Target Chamber is ready for beam (vacuum checked)

d. Roles and Responsibilities

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Person	WBS	Responsibility
Bogdan Wojtsekhowski (JLab) Gordon Cates (U.Va.) Kees de Jager (JLab)	1.	Project Scientists Technical Oversight
John LeRose (JLab)	1.	Project Management
Robin Wines (JLab)	1.	Hall A Engineering/Technical Support

e. Project Schedule

Figure 1 shows the project schedule of linked tasks and events with milestones and float for WBS 1 the SBS Basic project.

Activity ID	Activity Name	Start	Finish	Total Float
COSTED SBS BASIC 2011		01-Oct-12	31-Aug-15	365.00
1.01 MILESTONES		01-Oct-12	31-Aug-15	73.00
1.01.1 LEVEL 1 MILESTONES		01-Oct-12	31-Aug-15	73.00
1-01	Project Start	01-Oct-12*		0.00
1-05	Equipment Ready		31-Aug-15*	73.00
1.01.2 LEVEL 2 MILESTONES		21-Dec-12	21-Dec-12	415.00
2-01	Magnet Delivered	21-Dec-12		415.00
1.01.9 FUNDING MILESTONES		01-Oct-12	01-Oct-14	0.00
9-1300	FY13 Funds Available	01-Oct-12*		0.00
9-1400	FY14 Funds Available	01-Oct-13*		0.00
9-1500	FY15 Funds Available	01-Oct-14*		0.00
1.1 HALL A INFRASTRUCTURE		01-Oct-12	31-Aug-15	365.00
1.1.1 MAGNET		01-Oct-12	16-Jul-15	397.00
111000	Magnet Transportation	01-Oct-12	20-Dec-12	251.00
111005	Magnet Yoke Beamline Cut	01-Feb-13	31-May-13	392.00
111010	Vend Fab Magnet Field Clamp	01-Feb-13	31-May-13	392.00
111015	Magnet Power Engineering FY13	15-Jan-13	15-Apr-13	516.00
111020	Magnet Power Engineering FY14	15-Jan-14	01-May-14	331.00
111025	Vend Fab AC Infrastructure	02-May-14	31-Jul-14	331.00
111030	Vend Fab DC Bus	01-Apr-14	18-Aug-14	210.00
111035	Vend Fab LCW	01-Oct-14	27-Feb-15	191.00
111040	Vend Fab Power Supply	01-Oct-14	30-Jun-15	105.00
111045	Vend Fab New Coil	21-Dec-12	20-Dec-13	251.00
111050	Vend Fab Correction Coils	27-Mar-13	24-Sep-13	312.00
111055	Vend Fab Pole Shims	04-Mar-15	17-Jun-15	416.00
111059	Test Magnet	01-Jul-15	16-Jul-15	105.00
111060M	SBS Basic Magnet Complete		16-Jul-15	105.00
1.1.2 PLATFORM		01-Mar-13	05-May-15	154.00
112000	Vend Fab Detector Supports	01-Mar-13	31-Jul-13	251.00
112005	Vend Fab Magnet Platform	01-Oct-13	28-Feb-14	209.00
112010	Assemble Stand with Magnet and ready for GEMS	03-Mar-14	16-Feb-15	209.00
112015	Vend Fab Electronics Hut	19-Jan-15	05-May-15	154.00
112020	SBS Basic Platform Complete		05-May-15	154.00
1.1.3 BEAMLINE		13-May-14	31-Aug-15	73.00
113000	Vend Fab Beam Line Magnets	13-May-14	26-Aug-14	323.00
113005	Vend Fab Vacuum Snout Chamber	13-May-14	26-Aug-14	323.00
113010	Vend Fab Exit Vacuum Line	16-Mar-15	31-Jul-15	94.00
113015	Vend Fab Support Structure for Exit Pipe	01-Oct-14	31-Mar-15	179.00
113020	Vend Fab Lead Tube Platform	16-Mar-15	31-Aug-15	73.00
113025M	SBS Basic Beamline Complete		31-Aug-15	73.00

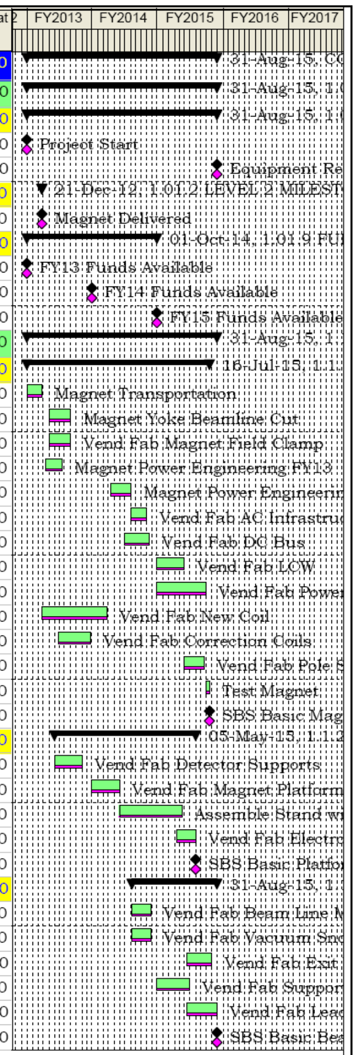

Figure 1: WBS 1, SBS Basic Project

Project Milestones

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Level	Milestone	Date
1	Project Start	1 Oct 2012
1	Equipment Ready	31 Aug 2015
2	Magnet Delivered	12 Dec 2012

Critical Path and Float Need

The critical path for the SBS Basic project is the *Vend Fab Lead Tube Platform* activity whose start date is constrained by FY15 funds availability. This activity has 73 days of total float based upon the must finish date for the project.

f. Project Costs ($K AY)

SBS Basic Profile		AY$K							
WBS		FY13	FY14	FY15	FY16	FY17	WBS Total	Contingency	Total
1.1.1	Magnet	$370	$166	$201	$0	$0	$737		
1.1.2	Platform	$75	$195	$133	$0	$0	$402		
1.1.3	Beamline	$0	$92	$134	$0	$0	$226		
	Total	$445	$452	$467	$0	$0	$1,365	$287	$1,652

Contingency Estimate

The original cost estimate is based on a spreadsheet where each item with numbers needed, unit costs, overheads as appropriate, escalation factors, and a best guess estimate of the contingency anticipated for each item included. Those contingencies were based on the current understanding of the costs and risks associated with each item. Those contingencies ranged from 0% to 30%. The contingency for just SBS basic in that scenario came out to 18%. For simplicity we have taken the average contingency from all three projects, 21%, and applied it to each project.

g. Project Risks

The overall risk for the magnet, platform and beamline elements of SBS Basic project is very low. They are all fairly standard items of a type we have dealt with before. The principal risk is the possibility that something as designed would not fit in its appointed place because of some unforeseen interference with existing equipment in the Hall. The main consequence of such an event would be a schedule impact caused by the time it would take to make modifications in the field to circumvent the interference. To mitigate that risk a detailed 3-dimensional model of the Hall is maintained. All designs are required to fit into that model with adequate margin that there be no interferences.

Risk Event	Cost of Event	Likelihood of Event	Mitigation Strategy
Magnet Risk	Mostly schedule impact	<1%	Careful, detailed design
Platform Risk	Mostly schedule impact	<1%	Careful, detailed design
Beamline Risk	Mostly schedule impact	<1%	Careful, detailed design

h. Project Quality Management

Hall A Infrastructure: Jefferson Lab has a long history of building and installing equipment and then running experiment with that equipment. Procedures and protocols already spelled-out and used daily will be used to ensure the quality of all installations in the Hall.

i. Program Transition to Operations

The Readiness Review process will address the final inspection and acceptance topic. Operations for the SBS Basic elements will proceed upon the successful completion of the Readiness Review.

9. The Neutron Form Factor Project

a. Project Scope

WBS and Dictionary

<table>
<tr><td rowspan="2">WBS 2.</td><td rowspan="2">Neutron Form Factor Project</td><td rowspan="2">This WBS element includes the design and construction of the Gas Electron Multiplier (GEM) tracking detectors sufficient for the neutron form factor measurements.</td><td rowspan="2">2.2</td><td rowspan="2">Detectors</td><td>2.2.1</td><td>GEMs</td></tr>
<tr><td>2.2.2</td><td>GEM Electronics</td></tr>
</table>

The detector package is comprised of large arrays of GEM detectors (eight GEM chamber layers of 50 x 200 cm^2 effective area with x-y readout; each layer will consist of five GEM modules each with a 40 x 50 cm^2 effective area) with attendant electronics, both front-end and Data Acquisition (~40,000 channels). All the electronics will be installed in the Hall for normal operation.

b. Project Deliverables

The University of Virginia and Norfolk State University will produce the deliverables for the Neutron Form Factor project:

- Gas Electron Multiplier (GEM) Tracking Detectors (UVa)
- Front-end and Data Acquisition Electronics (NSU)

c. Key Performance Parameters

- GEMs (20 modules) for the neutron form factor measurements must be in position and operational in the Hall (see "Project Quality Management" below for more details).
- GEM electronics and DAQ must be attached to the above GEMs and functional (see "Project Quality Management" below for more details) in an integrated Data Acquisition system.

d. Roles and Responsibilities

Person	WBS	Responsibility
Bogdan Wojtsekhowski (JLab) Gordon Cates (U.Va.) Kees de Jager (JLab)	2.	Project Scientists Technical Oversight
John LeRose (JLab)	2.	Project Management
Nilanga Liyanage (U.Va.)	2.2.1	GEM's
Mahbub Khandaker (NSU)	2.2.2	GEM Front-end and DAQ Electronics

e. Project Schedule

Figure 2 shows the project schedule of linked tasks and events with milestones and float for WBS 2, the Neutron Form Factor project.

Activity ID	Activity Name	Start	Finish	Total Float
COSTED SBS NEUTRON FORM FACTOR 2011		01-Oct-12	30-Sep-14	30.00
2.01 MILESTONES		01-Oct-12	03-Sep-14	20.00
2.01.1 LEVEL 1 MILESTONES		01-Oct-12	03-Sep-14	20.00
1-01	Project Start	01-Oct-12*		0.00
1-03	SBS Neutron Form Factor Ready for Experiment		03-Sep-14*	20.00
2.01.2 LEVEL 2 MILESTONES		19-Aug-13	03-Sep-14	20.00
1-23	NSU Receives Parts		10-Dec-13*	15.00
1-33	NSU Front End Electronics Assembled		14-Mar-14*	24.00
1-43	NSU Integration of FE and DAQ		03-Sep-14*	20.00
1-53	UVA Receives Parts		19-Aug-13*	30.00
1-63	UVA 20 GEM Modules Assembled		19-Aug-14*	30.00
2.01.9 FUNDING MILESTONES		01-Oct-12	01-Oct-13	0.00
9-1300	FY13 Funds Available	01-Oct-12*		0.00
9-1400	FY14 Funds Available	01-Oct-13*		0.00
2.2 DETECTORS		01-Oct-12	30-Sep-14	30.00
2.2.1 GEMS		01-Oct-12	30-Sep-14	30.00
221000	UVA Phase 2	01-Oct-12	30-Sep-13	30.00
221005	UVA Phase 3	01-Oct-13	30-Sep-14	30.00
2.2.2 GEM ELECTRONICS		01-Oct-13	30-Sep-14	15.00
222000	NSU Phase 1	01-Oct-13	30-Sep-14	15.00

Figure 2: WBS 2, Neutron Form Factor Project

Project Milestones

Level	Milestone	Date
1	Project Start	1 Oct 2012
1	SBS Neutron Form Factor Ready for Experiment	3 Sep 2014
2	NSU Receives Parts	10 Dec 2013
2	NSU Front End Electronics Assembled	14 Mar 2014
2	NSU Integration of FE and DAQ	3 Sep 2014
2	UVA Receives Parts	19 Aug 2013
2	UVA 20 GEM Modules Assembled	19 Aug 2014

Critical Path and Float

The critical path for the Neutron Form Factor project is the *NSU Phase 1* activity whose start date is constrained by FY14 funds availability. This activity has 15 days of total float based upon the must finish date for the project.

e. Project Costs

Neutron Form Factor Profile		AY$K							
WBS		FY13	FY14	FY15	FY16	FY17	WBS Total	Contingency	Total
2.2.1	GEMs	$304	$323	$0	$0	$0	$627		
2.2.2	GEM Electronics	$0	$262	$0	$0	$0	$262		
	Total	$304	$585	$0	$0	$0	$889	$187	$1,076

Contingency Estimate

The original cost estimate is based on a spreadsheet where each item with numbers needed, unit costs, overheads as appropriate, escalation factors, and a best guess estimate of the contingency anticipated for each item included. Those contingencies were based on the current understanding of the costs and risks associated with each item. Those contingencies ranged from 0% to 30%. The contingency for just WBS 2 in that scenario came out to 22%. For simplicity we have taken the average contingency from all three projects, 21%, and applied it to each project.

f. Project Risks

The overall risk for the GEM and GEM Electronics elements of Neutron Form Factor project is low. These are all known items with known performance capabilities. Failure of GEM foils is expected at a known rate and allowance for extras reflects that with 5% extra for insurance. Electronics likewise have well known failure rates. Since these risks are already accounted for in the allowance for extras the contingency allotted to them is somewhat lower than might otherwise be expected.

Risk Event	Cost of Event	Likelihood of Event	Mitigation Strategy
Failure of GEM Foil	$2k	~12%	Will have extras available 30% extra foils/20% extra chamber modules
Failure of GEM Electronics Module	$2k	~12%	Plan to make 18% extra modules

h. Project Quality Management

GEM Foils

The primary method of validating GEM foils would be testing GEM foils with high voltage up to 550 V in a dry nitrogen box. Currently we are fabricating a dry nitrogen high-voltage box for GEM foil testing. We will test the raw foils upon their arrival at UVa. We will test them again after framing. We have also setup a digital microscope and a light-box to visually examine the foils, in case the HV test indicates that a certain sector has problems.

Of course, we will ask Rui De Oliveira at CERN to test the foils using their HV testing method and validate them before shipping the foils to UVa. We are now hiring Dr. Kondo Gnanvo as a research scientist at UVa. Dr. Gnanvo has many years of experience working with the Rui De Oliveira's group. Dr. Gnanvo will travel to CERN before GEM foil shipments to UVa to work with Rui's group to ensure the quality of the GEM foils.

Front End Electronics/DAQ

The quality control tools and techniques for the GEM-based trackers are based on the following sources of information:

- Technical notes describing the construction and quality control of the GEM detectors for the COMPASS and TOTEM T2 experiments at CERN (M. Capeans *et al*., CERN-EP/TA1 – Technical Note TA1/00-03, February 17, 2001, and T. Hilden's lecture at the RD51 collaboration, CERN, February 17-20, 2009).
- The technical specifications of the custom built VME multi-purpose digitizer (MPD) modules that have been designed and developed by the INFN-Rome group (Dr. E. Cisbani as the principal investigator) for the APV25 chips on the front-end card.

Test Approach

- Visual inspection of the APV25 front-end cards and the VME MPD modules.
- Test of the electronics with a full scale (40x50 cm2) prototype GEM chamber with the test setup existing in the EEL building at JLab.
- High voltage test, up to HV=650 V, of the GEM foil resistance in Ar/CO2 gas mixture for the chambers.
- Look for signals and noise levels from the APV25 readout boards.
- Capacitance measurements of the readout boards.

Performance/Quality Standards

- Pulse shaping time for the APV25 amplifier in peak mode should be ~50 ns with no (or very little) undershoot.
- The amplified signal noise level is dominated by the voltage noise source in the chambers. The Equivalent Noise Charge (ENC), which is roughly proportional to the detector capacitance, should be ~3100 e- rms for the polarimeter GEM trackers (with 280 cm long strips and four strips combined) corresponding to a capacitance of ~80 pF.
- The pulse shape should not change significantly with increasing load capacitance.
- ENC for APV25 readout should be linear as a function of load capacitance with a slope of ~36 e- rms/pF.
- The noise level in peak mode at 0 pF should be ~250 e- rms.

Quality Management Roles
The front-end and DAQ electronics of the GEM-based trackers of the Super Bigbite project is responsibility of the Norfolk State University group. The quality assurance and all the work for the electronics will be supervised by the principal investigators of this sub-system of the project, Drs. M. Khandaker and V. Punjabi. They will be assisted by a FTE electronics technician and undergraduate students during the entire course of assembly and testing of the electronics.

i. Project Transition to Operations

The Readiness Review process will address the final inspection and acceptance topic. Operations for the Neutron Form Factor elements will proceed upon the successful completion of the Readiness Review.

10. The Proton Form Factor Project

a. Project Scope

WBS and Dictionary

WBS 3.	**Proton Form Factor Project**	This WBS element covers the development of the full SBS system including the construction of the full complement of Gas Electron Multiplier (GEM) tracking detectors sufficient for the proton form factor measurements, the shims required to the magnet, and the beamline shielding.	**3.1**	Hall A Infrastructure	**3.1.2**	Platform
					3.1.3	Beamline
			3.2	Detectors	**3.2.1**	GEMs
					3.2.2	GEM Electronics
					3.2.3	Trigger

b. Project Deliverables

Jefferson Lab, the College of William & Mary, the University of Virginia, Norfolk State University, and Rutgers University will produce the deliverables for the Proton Form Factor project:

- Target Cell Construction (JLab)
- Shielding (JLab)
- Detector Frames Design and Construction (JLab)
- Dipole Magnet Shims (JLab)
- Dipole exit field clamp
- Detector Support Frames and Associated Mechanics (W&M)
- Gas Electron Multiplier (GEM) Tracking Detectors (UVa)
- Front-end and Data Acquisition Electronics (NSU)
- Trigger (RU)

c. Key Performance Parameters

- Magnet Modifications for WBS 3. include pole shims and exit field clamp installed with field <0.1 T at the first GEM. $\int Bdl > 2.4$ T-m along the central trajectory path is also required
- All needed GEMs must be in position and operational in the Hall (see “Program Quality Management” for more details).
- GEM electronics and DAQ must be attached to the above GEMs and functional (see “Program Quality Management” for more details).

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d. Roles and Responsibilities

Person	WBS	Responsibility
Bogdan Wojtsekhowski (JLab) Gordon Cates (U.Va.) Kees de Jager (JLab)	3.	Project Scientists Technical Oversight
John LeRose (JLab)	3.	Project Management
Robin Wines (JLab)	3.1	Hall A Engineering/Technical Support
Nilanga Liyanage (U.Va.)	3.2.1	Hall A Engineering/Technical Support
Charles Perdrisat (W&M)	3.2.1	Chamber Supports
Mahbub Khandaker (NSU)	3.2.2	Front-end and DAQ Electronics
Ron Gilman (RU)	3.2.3	Trigger

e. Project Schedule

Figure 3 shows the project schedule of linked tasks and events with milestones and float for WBS 3, the Proton Form Factor project.

Activity ID	Activity Name	Start	Finish	Total Float
COSTED SBS PROTON FORM FACTOR 2011		01-Oct-13	13-Jan-17	11.00
3.01 MILESTONES		01-Oct-13	13-Jan-17	11.00
3.01.1 LEVEL 1 MILESTONES		01-Oct-14	13-Jan-17	11.00
1-01	Project Start	01-Oct-14*		0.00
1-04	SBS Proton Form Factor Ready for Experiment		13-Jan-17*	11.00
3.01.9 FUNDING MILESTONES		01-Oct-13	03-Oct-16	0.00
9-1400	FY14 Funds Available	01-Oct-13*		0.00
9-1500	FY15 Funds Available	01-Oct-14*		0.00
9-1600	FY16 Funds Available	01-Oct-15*		0.00
9-1610	FY17 Funds Available	03-Oct-16*		0.00
3.1 HALL A INFRASTRUCTURE		01-Oct-15	13-Jan-17	11.00
3.1.2 PLATFORM		01-Oct-15	13-Jan-17	11.00
312000	Procure Lead Shielding	01-Oct-15	29-Jan-16	249.00
312005	Vend Fab Detector Supports (Frames)	03-Oct-16	13-Jan-17	11.00
312010M	SBS Proton Form Factor Platform Complete		13-Jan-17	11.00
3.1.3 BEAMLINE		01-Oct-15	31-Mar-16	206.00
313000	Target Cell	01-Oct-15	31-Mar-16	206.00
313005M	SBS Proton Form Factor Beamline Complete		31-Mar-16	206.00
3.2 DETECTORS		01-Oct-14	03-Oct-16	77.00
3.2.1 GEMS		01-Oct-14	03-Oct-16	77.00
321005	UVA Phase 4	01-Oct-14	01-Oct-15	77.00
321010	UVA Phase 5	02-Oct-15	03-Oct-16	77.00
321015	W&M Effort	02-Feb-15	31-Jul-15	120.00
3.2.2 GEM ELECTRONICS		01-Oct-14	30-Sep-15	326.00
322000	NSU Phase 2	01-Oct-14	30-Sep-15	326.00
3.2.3 TRIGGER		01-Apr-15	29-Jul-16	122.00
323000	Rutgers Phase 1	01-Apr-15	31-Jul-15	164.00
323005	Rutgers Phase 2	01-Oct-15	29-Jul-16	122.00

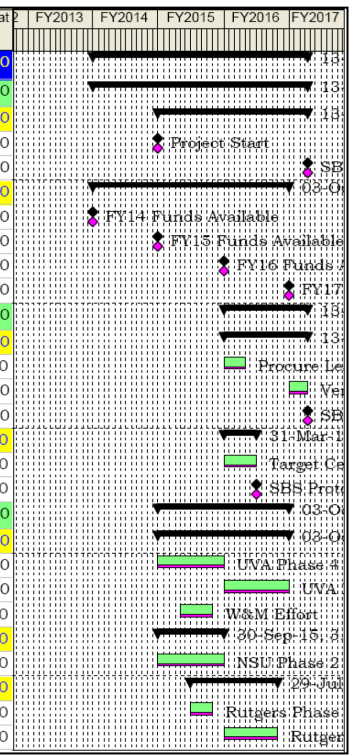

Figure 3: WBS 3, Proton Form Factor Project

Project Milestones

Level	Milestone	Date
1	Project Start	1 Oct 2014
1	SBS Proton Form Factor Ready for Experiment	13 Jan 2017

Critical Path and Float

The critical path for the Proton Form Factor project is the *Vend Fab Detector Supports (Frames)* activity whose start date is constrained by FY17 funds availability. This activity has 11 days of total float based upon the must finish date for the project.

e. Project Costs

Proton Form Factor Profile		AY$K							
WBS		FY13	FY14	FY15	FY16	FY17	WBS Total	Contingency	Total
3.1.2	Platform	$0	$0	$0	$102	$66	$168		
3.1.3	Beamline	$0	$0	$0	$48	$0	$48		
3.2.1	GEMs	$0	$0	$481	$225	$0	$706		
3.2.2	GEM Electronics	$0	$0	$194	$0	$0	$194		
3.2.3	Trigger	$0	$0	$28	$176	$0	$204		
	Total	$0	$0	$703	$551	$66	$1,320	$277	$1,597

Contingency Estimate

The original cost estimate is based on a spreadsheet where each item with numbers needed, unit costs, overheads as appropriate, escalation factors, and a best guess estimate of the contingency anticipated for each item included. Those contingencies were based on the current understanding of the costs and risks associated with each item. Those contingencies ranged from 0% to 30%. The contingency for just WBS 3 in that scenario came out to 25%. For simplicity we have taken the average contingency from all three projects, 21%, and applied it to each project.

f. Project Risks

The overall risk for the platform, beamline, and trigger elements of Proton Form Factor project is very low; risk for the GEM Foil and GEM Electronics is low. These are all known items with known performance capabilities. Failure of GEM foils is expected at a known rate and allowance for extras reflects that with 5% extra for insurance. Electronics likewise have well known failure rates. Since these risks are already accounted for in the allowance for extras the contingency allotted to them is somewhat lower than might otherwise be expected.

Risk Event	Cost of Event	Likelihood of Event	Mitigation Strategy
Platform Risk	Mostly schedule impact	<1%	Careful detailed design
Beamline	Mostly schedule impact	<1%	Careful detailed design

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Risk			
Failure of GEM Foil	$2k	~12%	Will have extras available 30% extra foils/20% extra chamber modules
Failure of GEM Electronics Module	$2k	~12%	Plan to make 18% extra modules
Trigger Risk		<1%	none

h. Project Quality Management

GEM Foils and Front End Electronics/DAQ

See discussion under section 9h.

Trigger

The final trigger configuration will be a ready to use integrated hardware and software package. It will be considered complete when it is successfully tested with pulsers and cosmic rays while connected to the detectors.

i. Project Transition to Operations

The Readiness Review process will address the final inspection and acceptance topic. Operations for the Neutron Form Factor elements will proceed upon the successful completion of the Readiness Review.