

## WASP Manufacturing Status Review

February 2, 2021 ASEN 4028-011 Team 9

**Company Customer:** Sierra Nevada Corporation (SNC)

**Faculty Advisor:** Dr. Francisco Lopez Jimenez

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Additional Team Members: Maddie Dube, Adam Elsayed, Samuel Felice, Aidan Kirby, Parker Simmons



## **Presentation Outline**

- 1. Project Overview
- 2. Updates since CDR
- 3. Schedule for Spring Semester
- 4. Manufacturing Plan
- 5. Budget Review



## **Project Overview**

## **Project Overview**

### Background:

 Sierra Nevada Corporation's ISR, Aviation, and Security (SNC IAS) division needs a better way of measuring the weight and CG of their Intelligence, Surveillance, and Reconnaissance (ISR) pods.

### Motivation:

- Effective: Current method of finding weight and CG is challenging.
- **Safety:** ISR Pods and Engineers are at risk with current method.





## **Primary Project Objectives**



- Measure the weight and CG location of SNC ISR Pods to an accuracy of ±0.1% and ±0.1 inch, respectively.
- 2. Be able to use WASP for pods weighing up to **2000 lbs**.
- 3. Be able to accomodate pods with **14-inch** and **30-inch** lug spacing configurations.
- 4. Develop a measurement procedure for WASP that is feasible for SNC test engineers (**30-minute** test duration, **2 engineers**)



## **Concept of Operations**



## **Baseline Design**







## **Functional Block Diagram**



## **Critical Project Elements**



CPE	Description	FR
E1	All static possible loading must be handled by the frame. It must be portable and support at least 2000 lbs.	FR3, FR4
E2	WASP should rigidly interface with lugs for all pod types.	FR3
E3	WASP must be capable of weight measurements with $\pm 0.1\%$ of true value; CG measurements within $\pm 0.1$ " of true value.	FR1, FR2
E4	Testing procedures for weight and CG calculations must be well-developed.	FR5
E5	Since heavy loads are involved, both the pods and WASP operators should be safe from harm.	FR5



## **Project Updates**

## **Redesign of Tilt Stopping Method**





#### Overview Project Updates

## Lug Mount Tensile Test

DR 3.1: WASP shall support pods of 2000 lbs with a FOS of 2.0 to make safe and accurate measurements

- Objective:
  - 2000 lb lug mount identified as critical component: FOS
     3.0 (SolidWorks FEA model)
  - Quantify useable strength of this component
- Plan:
  - Test lug assembly to failure using Electromechanical MTS machine
- Measurements:
  - Yield and failure load using MTS software
  - Identify exact failure mode of the complex geometry
- Pass Criteria:
  - FOS > 2.0
  - Verify/modify FEA model









## Schedule



## **Spring Semester Timeline**

Tak         Media         M	WASP									J	anuary	,		Feb	oruary			M	arch			Apr	ril	May	
Networks         Status         Unit	Task	Duration (weeks)	Margin (weeks)	Planned Start Date	Actual Start Date	Planned End Date	Deadline Date	Actual End Date	Week of:	1/11	1/18	1/25	2/1	2/8	2/15	2/22	3/1	3/8 3	3/15 3/22	3/29	4/5	4/12	4/19 4/26	5/3 5/1	
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## **Spring Semester Timeline - Critical Path**

WASP										Januar	у		Feb	oruary				Ma	rch				A	pril		N	lay							
Task	Duration (weeks)	Margin (weeks)	Planned Start Date	Actual Start Date	Planned End Date	Deadline Date	Actual End Date	Week of:	1/11	1/18	1/25	2/1	2/8	2/15	2/22	3/1	3/8	3/	15 3	/22	3/29	4/5	4/12	4/1	4/26	5/3	5/10	Г		$\wedge$	1.00	0.000		-
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Lug Mount Tensile Test	1	0.5	2/8		2/15	2/18																		0	1000									
Setup WASP for Structural Test	0.5	0.5	3/8		3/11	3/15																		Sys	stem	100								
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## **Manufacturing Plan**

## **Structural Manufacturing - Scope**



Job-Shop Model (2/15)
Lug pins
Lug mounts (tops and bottoms)
Plastic sliding plates
Pinned sliding interface plates
Cleats for legs and sliding interface beams
Axles and support blocks
Force sensor attachment blocks and screws
Pin housings
Shackle attachment blocks
MTS-Force sensor attachment bar

Team-Manufa	ctured (2/15)
Process	Tool
Beams	(x 17)
Cut to length	Band Saw
Cut ends and weld	Angle Grinder
Drill Holes for pins	Milling Machine
Legs	(x 4)
Cut to length	Band Saw
Drill holes for pins	Milling Machine
Forklift sl	ots (x 2)
Cut from steel sheet	Band Saw/Plasma Cut
Weld together	Welding Torch

COTS (2/5)
CM Chain Hoist
CM Hoist Trolley
Axle bearings
All fasteners (bolts, nuts, washers, COTS pins)

Expected Time
5-15 person-hours
15-25 person-hours
25+ person-hours



## **Structural Manufacturing - Assembly Plan**

#### Assemble Segments of WASP



#### Assemble WASP Frame from Segments



#### Attach Additional Components





## **Structural Manufacturing - Assembly Plan**

### **Assemble WASP Frame from Segments**





## **Structural Manufacturing - Current Status**

#### **Completed:**

- Raw Material delivered
- COTS Parts delivered\*
- Parts submitted (23)
- Parts completed (8)

\* shackles expected delivery 2/5

#### **Parts Submitted:**



#### Not pictured: 2000-lb Lug Mount Bottoms



Overview Project Updates Schedule Manufacturing: Structure - Electronics - Software

### **Structural Manufacturing - Current Status**







Beam weld preparation

Cutting beams to length



## **Structural Manufacturing - Current Status**

#### Parts In Progress:

#### Tilting Mechanism Axle

100 lb Lug Mount Bottoms

1000 lb Lug Mount Bottoms

TP Lug Mount Bottoms

100 lb Lug Pins

1000 lb Lug Pins

Tilting Mechanism Block

Force sensor attachment blocks - testbed side

Force sensor attachment blocks - sliding interface side

Outer pin houses

Inner pin houses

Double-threaded screws for force sensors

Sliding plate flush with I-beam cross section Sliding plate that runs along the length of the I-beam

Shackle Blocks

#### ECD: February 15th

#### Future Work:

#### **Team Manufacturing** (135 person-hours)

- Beams
- Legs
- Forklift Slots

#### ECD: February 15th

#### Subassemblies (140 person-hours)

• Sliding Interface/Testbed

ECD: February 22nd

#### Final Assembly (130 person-hours)

- Outer frame
- Load
- Integration

#### ECD: March 8th

ECDs based on time estimates for each task vs. 93 person- hour scheduled work week



## **Electrical Manufacturing - Overview**

#### **Off-the-Shelf Components**





Omega LC103B [8] Wyler Clinotronic Plus [10] NI 9237 DAQ [14]





DSUB-37 Backshell [18]

DSUB-37 Connector [17]



Strain Gauges [11] 4-pin Connectors [19] [20]

#### **Require Fabrication**

- 1. DAQ Harness (DSUB-37 to 4-pin Male Connectors)
- 2. Instrument Connectors (4-pin Female Connectors)

DAQ and Load Cells Electrical Schematic



NI cDAQ 9171 [15]



## **Electrical Manufacturing - Status**

#### **Electrical Hardware**

#### Harnessing

Electrical Items	Status	Electrical Items	Status	Hours to Complete	Completion Date
Omega LC103B	SNC, Delivered	DAQ	Gathering	2	Echruczy Oth
Wyler Clinotronic Plus	SNC, In stock	Harnesses	supplies	۷	February our
NI 9237 DAQ	AES Inventory	Load Cell Harness	Gathering supplies	1.5	February 8th
NI cDAQ 9171	AES Inventory	Strain Gauge	Gathering	0.5	
DSUB-37 Connector/	AES Inventory	Harness	supplies	0.5	March 15th
Backshell	ALO Inventory				
Strain Gauges	Ordering/AES			Compl	etion
	Inventory			Comp	lete
4-pin Connector	WASP, Ordering			In-prog	Iress



## **Software Manufacturing - Overview**



## WASE OF

## **Software Manufacturing - Status**

Software Item	Status	Assigned Engineers	Hours to Complete	Completion Date
Git Repository Setup	Completed	-	-	January 24th
Load Cell Characterization (LCC) Script	Flowchart: Under Review Script: Starting	Sam/Bailey	6	February 8th
Structural Integrity (SI) Script	Flowchart: Starting Script: Starting	Sam/Bailey	8	March 15th
Accuracy Script	Flowchart: Revising Script: Integrating Data Collection & Wt/CG Calculation Scripts	Emma/Sam	15	March 29th
User (GUI) Script	Flowchart: Under Review Script: Menu developed (IP)	Bailey/Ansh	18	April 12th
System Accreditation (SA) Script	Flowchart: Revising Script: Starting	Ansh/Bailey	30	April 12th

Completion Complete

In-progress





## **Budget Review**

#### **Future Expenses**

Item	Cost
Welding gas	\$75
Strain gauges	\$133 + shipping
Safety Placards	\$100



#### **Anticipated Margins**

Item	Cost
A36 I-Beam - 10' (Length of longest beam)	\$165
A36 Square Tube - 8' (Length of one leg)	\$50
A36 Bar	\$50
Extra Fasteners	\$50
Improvements (Caster wheels)	\$350
	Total: \$615



### **Acknowledgements**

#### SNC Team:

Becky Vander Hoeven, Gary Hutton, Stephen McLaughlin, Jon Matula, AJ Olson

#### Advisory Board Members and AES Faculty:

Dr. Allison Anderson, Lara Buri, Dr. Donna Gerren, Camilla Hallin, Professor Bobby Hodgkinson, Dr. Jelliffe Jackson, Dr. Francisco Lopez Jimenez, Professor Matt Rhode, Professor Trudy Schwartz, Dr. Zachary Sunberg, Dr. Kathryn Wingate

#### **MSR Reviewers:**

Lara Buri, Dr. Francisco Lopez Jimenez

#### Thank you to everyone who supported the WASP Team!



## **Questions?**



### **References**

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# **Back-Up Material**



## **Structural Manufacturing**



## **Manufacturing Schedule**

						r	laster S	chedule							
		Monday			Tuesday			Wednesday			Thursday			Friday	
	Person 1	Person 2	Person 3	Person 1	Person 2	Person 3	Person 1	Person 2	Person 3	Person 1	Person 2	Person 3	Person 1	Person 2	Person 3
9:00	Maddie	-	Adam	Emma	Maddie	Adam	Maddie	Adam		Emma	Adam				
9:30	Maddie		Adam	Emma	Maddie	Adam	Maddie	Adam		Emma	Adam				
10:00	Maddie		Adam	Emma	Maddie	Adam	Maddie	Adam		Emma	Adam	Aidan			
10:30	Maddie		Adam	Emma	Maddie	Adam	Maddie	Adam		Emma	Adam	Aidan			
11:00	Maddie	Foster	Adam	Emma	Maddie	Adam		Adam	Foster	Emma	Adam	Aidan	Foster	Aidan	
11:30	Maddie	Foster	Adam	Emma	Maddie	Adam		Adam	Foster	Emma	Adam	Aidan	Foster	Aidan	Emma
12:00	Aidan	Foster	Adam	Emma	Maddie		Aidan	Adam	Foster	Emma	Maddie	Aidan	Foster	Aidan	Emma
12:30	Aidan	Foster	Adam	Aidan	Maddie	5. 	Aidan	Adam	Foster		Maddie	Aidan	Foster	Aidan	Emma
1:00			2	Aidan	Maddie	Foster				Foster	Maddie	Aidan	Foster	Aidan	Emma
1:30				Aidan	Maddie	Foster				Foster	Maddie	Aidan			
2:00	Aidan	Parker	Ansh		Ansh	Foster	Aidan	Ansh	Parker	Foster	Maddie	Ansh			
2:30	Aidan	Parker	Ansh		Ansh	Foster	Aidan	Ansh	Parker	Foster		Ansh	Parker	Aidan	
3:00	Maddie	Parker	Ansh	Parker	Ansh	Foster	Emma	Ansh	Parker	Foster	Parker	Ansh	Parker	Aidan	
3:30	Maddie	Parker	Ansh	Parker	Ansh	Foster	Emma	Ansh	Parker	Foster	Parker	Ansh	Parker	Aidan	
4:00	Maddie	Parker	Ansh	Parker	Matt	Foster	Emma	Ansh	Parker	Foster	Parker	Matt	Parker	Aidan	
4:30	Maddie	Parker	Ansh	Parker	Matt	Foster	Emma	Ansh	Parker	Foster	Parker	Matt	Parker	Aidan	
	Name	Default setti	ng, what yo	u are schedu	led for			Allowe	d Number of	Call Out Hou	urs for This \	Week:			
Key :	Name	To indicate t	hat you can	make your s	cheduled shift										
	Name	To indicate t	hat you can	't make your	scheduled shif	ť			There shoul	d always be a	it least two pe	eople on a s	hift. If you ca	all out of a 3	
	Name	To indicate t	hat you can	work extra h	ours or fill in fo	or someone	-	Protocol:	person shift,	you do not n	eed to find a	replacemer	t. If you call	out of a 2	
									person shift,	you need to	find someone	e to cover yo	our spot		

Iring: Structure - Electronics - Software



## **Assembly Mechanical Drawing**




## **Job-Shop Parts: Mechanical Drawings**



### **020 Leg Cleat**





## **021 Sliding Bracket**





### **022 Tilting Axle**





### **023 Tilting Block**





### **024 Sliding Plate**





### **025 Outer Plastic Sliding Plate**





### **026 Inner Plastic Sliding Plate**





## 027 Lug Mount Top





### 028 TP Lug Mount Top



SOLIDWORKS Educational Product. For Instructional Use Only.



### 029 100lb Class Lug Mount Bottom





### 030 1000lb Class Lug Mount Bottom





### 031 2000lb Class Lug Mount Bottom





## **032 TP Lug Mount Bottom**





### 033 100lb Class Lug Pin





## 034 1000lb Class Lug Pin





### 035 2000lb Class Lug Pin





### **036 Testbed Force Sensor Attachment Block**



# 037 Sliding Interface Force Sensor Attachment Block





### **038 Outer Testbed Leveling Pin Housing**





### **039 Inner Testbed Leveling Pin Housing**





### **043 Force Sensor Adapter Screw**





### **044 Leg Bottom Interface Plate**





### **046 Force Sensor Bumper Bar**





### **047 Testbed Shackle Attachment Block**





# **Electronics Hardware**



### **Omega LC103B Load Cells [8]**



Specifications:

Accuracy (>25lb): class C3 Approvals(>25lb): OIML R60 Output sensitivity (mV/V): 3.0±0.008 (≤25/b 2.0±0.006) Maximum number of load cell intervals (nLC): 3000 Ratio of minimum LC verification interval (Y=Emax/vmin): 10000 Combined error (%FS): ±0.020 Minimum dead load: 0 Safe overload (%FS): 150% Ultimate overload (%FS): 300% Zero balance (%FS): ±1.0% Excitation, recommended voltage (V): 5 to 12(DC) Excitation maximum (V): 18(DC) Input resistance ( $\Omega$ ): 430 ± 50 Output resistance ( $\Omega$ ): 351 ± 2 Insulation resistance (M $\Omega$ ):  $\geq$  5000 (50VDC) Compensated temperature (°C): -10 to 40 Operating temperature (°C): -35 to 65 Storage temperature (°C): -40 to 70 Element material: Stainless steel Ingress protection (according to EN 60529): IP67 Recommended torque on fixation (Thread:lbf.ft):1/4"UNF:18 1/2"UNF:55 3/4"UNF:330 1"UNF:550 1 1/8"UNF:1070 Recommended torgue on fixation (Thread:Nm):M8:25 M12:75 M20:450 M24:750 M30:1450

## Wyler AG Clinotronic Plus [10]





Measuring range Messbereich		± 10 Arcdeg	± 30 Arcdeg	± 45 Arcdeg ± 60 Arcdeg
Calibration / Kalibrierung	Last values at: / letzte Werte bei:	± 10 Arcdeg	± 30 Arcdeg	± 50 Arcdeg resp. ± 60 Arcdeg
Limits of Error / Fehlergrenze		< 1 Arcmin + 1 Digit	< 1.5 Arcmin + 1 Digit	< 2 Arcmin + 1 Digit
Settle time / Messzeit	Value available after / Anzeige nach:		< 2 Secs.	
Resolution / Auflösung	Dep. on units set / abhängig von Einstellung	> 5 Arcsec (0.025 mm/m)		
Temp. Coeff. / Temperatur-Koeff.	Zero and scale / Null und Skala		< 0.01 Arcdeg./°C	;
Data connection / Anschluss		RS485 / asynchron /	7 Bit / 2 Stop Bit /	no parity / 9600 Baud
Battery / Batterie		1)	Size AA 1.5V Alka	aline



## NI 9237 Bridge Module [14]

DATASHEET

# NI 9237

4 AI, ±25 mV/V, 24 Bit, 50 kS/s/ch Simultaneous, Bridge Completion



- 4 channels, 50 kS/s per channel simultaneous AI
- $\pm 25 \text{ mV/V}$  input range, 24-bit resolution
- Programmable half- and full-bridge completion with up to 10 V internal excitation
- 60 VDC, Category I bank isolation
- RJ50 or D-SUB connectivity options
- -40 °C to 70 °C operating range, 5 g vibration,
  50 g shock

http://www.ni.com/pdf/manuals/374186a\_02.pdf



### NI 9237 Pinout/ Signal Descriptions [14]

### Signal Descriptions



### Table 1. NI 9237 Signal Descriptions

Signal Name	Description	
AI+	Positive analog input signal connection	
AI-	Negative analog input signal connection	
RS+	Positive remote sensing connection	
RS-	Negative remote sensing connection	
EX+	Positive sensor excitation connection	
EX-	Negative sensor excitation connection	
T+	TEDS data connection	
T-	TEDS return connection	
SC	Shunt calibration connection	

## NI cDAQ-9171 Compact DAQ [15]





#### DEVICE SPECIFICATIONS

## NI cDAQ<sup>™</sup>-9171

NI CompactDAQ One-Slot Bus-Powered USB Chassis

These specifications are for the NI cDAQ-9171 chassis only. These specifications are typical at 25 °C unless otherwise noted. For the C Series module specifications, refer to the documentation for the C Series module you are using.

### Analog Input

Input FIFO size	127 samples
Maximum sample rate <sup>1</sup>	Determined by the C Series module
Timing accuracy <sup>2</sup>	50 ppm of sample rate
Timing resolution <sup>2</sup>	12.5 ns
Number of channels supported	Determined by the C Series module

### Analog Output

Number of channels supported			
Hardware-timed task			
Onboard regeneration	16		
Non-regeneration	Determined by the C Series module		
Non-hardware-timed task	Determined by the C Series module		
Maximum update rate			
Onboard regeneration 1.6 MS/s (multi-channel, aggregate			
Non-regeneration Determined by the C Series module			
Timing accuracy	50 ppm of sample rate		
Timing resolution	12.5 ns		
Output FIFO size			
Onboard regeneration	8,191 samples shared among channels used		
Non-regeneration	127 samples		
AO waveform modes	Non-periodic waveform, periodic waveform regeneration mode from onboard memory, periodic waveform regeneration from host buffer including dynamic undate		

https://www.ni.com/pdf/manuals/374037b.pdf



### MicroMeasurements CEA-06-250UW-350 Strain Gauge [16]

### CHARACTERISTICS

Gage Length: 250 Resistance (Ω): 120,175,350,1000,120,175,350 Series: CEA,W2A STC: 00,06,13,05,15,03,09 Options: P2,SP11 Dimensions:



Gage Length	Overall Length	Grid Width	Overall Width	Matrix Length	Matrix Width
0.25 in.	0.45 in.	0.18 in.	0 <mark>.1</mark> 8 in.	0.55 in.	0.27 in.
6.35 mm	11.43 mm	4.57 mm	4.57 mm	14 mm	6.9 mm

https://micro-measurements.com/pca/detail/250uw



### **DSUB-37 Connectors and Backshell [17] [18]**

Connector [17]

Backshell [18]





https://www.digikey.com/en/products/detail/norcomp-inc /171-037-103L001/858153 https://www.digikey.com/en/products/detail/cinch-conn ectivity-solutions-aim-cambridge/40-9737H/3830312



## 4-Pin Connectors [19] [20]

### Male, B4B-XH-A(LF)(SN) [19]



https://www.digikey.com/en/products/detail/jst-sales-america-inc/B4B-XH-A(LF)(SN)/1651047?utm\_adgroup=Rectangular%20Connectors% 20-%20Headers%2C%20Male%20Pins&utm\_source=google&utm\_m edium=cpc&utm\_campaign=Shopping\_Product\_Connectors%2C%20 Interconnects\_NEW&utm\_term=&utm\_content=Rectangular%20Conn ectors%20-%20Headers%2C%20Male%20Pins&gclid=CjwKCAiAo5q ABhBdEiwAOtGmbhvw5bEfvam07AKWoDuHVHM6lvxH-ya19nDYdG UTEexmRweBrGN6khoCbgoQAvD\_BwE

### Female, 04JQ-BT [20]



https://www.digikey.com/en/products/d etail/jst-sales-america-inc/04JQ-BT/49 18835



## **Caster Wheels [21]**







Mount Type	Stem
Wheel	
Diameter	2 1/2"
Width	1 1/8"
Number of	1
Mount Height	4 1/16"-4 5/8"
Capacity per Caster	1,100 lbs.
Hardness Rating	Hard
Hardness	Durometer 70D
Stem Type	Threaded
Stem Shape	Round
Stem Thread Size	1/2"-13
Stem Length	1 1/4"
Adjustment	
Style	Ratchet
Wheel/Tread Material	Nylon Plastic
Tread Shape	Flat
Nonmarking Wheels	Yes
Wheel Color	Black
Wheel Type	Solid
Wheel Bearing Type	Without Bearing

### https://www.mcmaster.com/2445T24/

