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International Council on Systems Engineering

A better world through a systems approach

Engineering Hope: A Rapid Systems Engineering Approach

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Meet the Authors

Calen Sims

Systems Engineer/ELDP, Lockheed Martin
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Calen is a Systems Engineer at Lockheed Martin specializing in HWIL testing, integration, and Model-Based Systems Engineering. With a background in embedded software, systems integration and DevSecOps, he previously served as a Computer Engineer with the U.S. Navy and now mentors engineering students at Florida State University Panama City part-time.

David C. Gross, PhD

Teaching Faculty; Systems Engineering Program- Florida State University (FSU)

David C. Gross is an expert in model-based systems engineering, digital engineering, and simulation, with leadership experience at Boeing and Lockheed Martin. He has driven innovations valued over $1 billion and now serves as a faculty member at Florida State University.

Kathleen Ticer

Requirements Manager, USAF
Graduate Student Florida State University

Kathleen is a seasoned communications, surveillance, and IT professional with 16 years of decorated service in the U.S. Air Force. She has performed flight communications operations senior government leaders and applied systems engineering to meet the requirements and acquisitions of executive airlift missions.

Introduction and Background

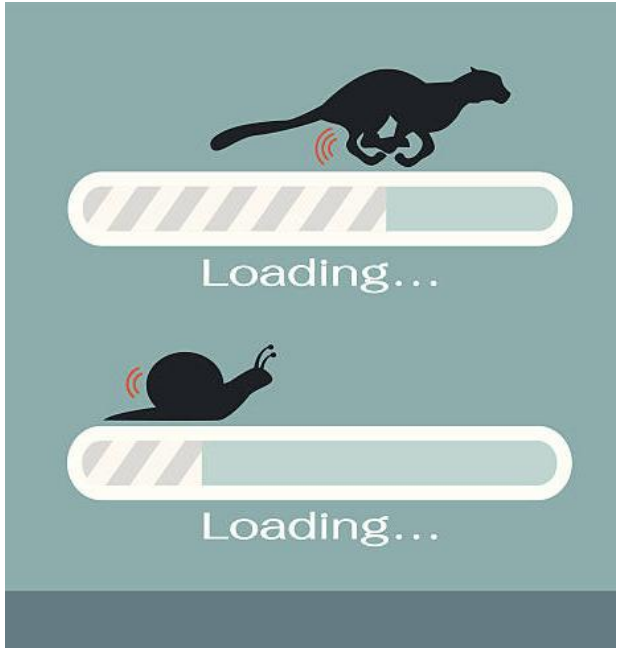
35th Annual INCOSE international symposium

hybrid event

Ottawa, Canada
July 26 - 31, 2025

What is "Rapid" Systems Engineering?

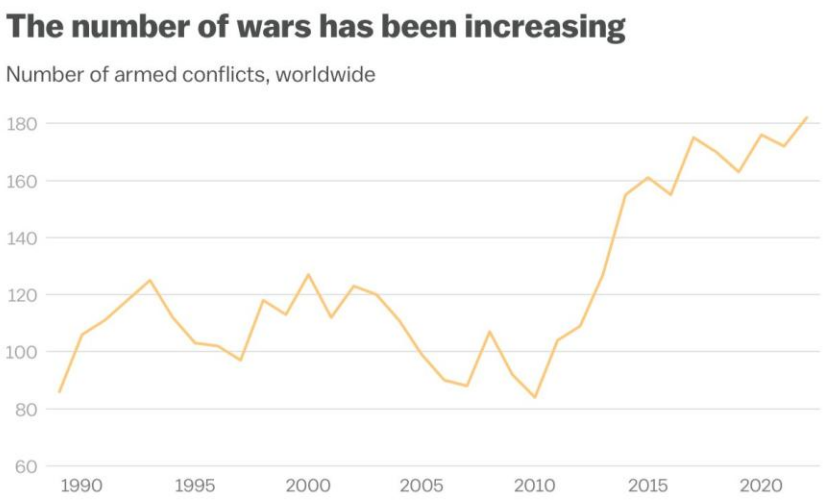
- **Systems Engineering Today:** Often seen as a long, drawn-out process with frequent delays and inefficiencies.
- **Rapid Systems Engineering:** A streamlined approach focused on speed, adaptability, and real-time decision-making.
  - **Key Focus:** Accelerating development timelines without compromising quality or performance.
  - **Benefits:** Faster deployment, quicker problem-solving, and more agile responses to changing requirements.
  - **End Goal:** Delivering optimized systems with reduced lead times and increased flexibility.



Systems Engineering and Disaster Relief

Disasters and war damaged environments are increasing in frequency and severity worldwide.

- **Challenges:**
  - Fast response and danger avoidance
  - Real-time damage assessment and decision-making
  - Multilateral and multiorganizational coordination
- **Why Systems Engineering (SE)?**
  - Complex System-of-systems integration
  - Rapid prototyping & iterative design
  - Multi-discipline synergies
  - Stakeholder-driven adaptability



Testbed: FSU-KNU Hackathon

- **Event:** Five-day virtual international Hackathon
- **Problem Posed:** Both Ukraine and Florida are experiencing catastrophic damage to cities from war and hurricanes, respectively. How might we assess building damage and estimate the cost of reconstruction working remotely using advanced technologies?
- **Solution Framework:** Design a scalable disaster assessment system in just five days using drone imagery as input. The system must return cost estimates of damage to make recovery decisions on repair and rebuild of urban areas in near-real time
- **Our Team and Solution?:** ClearSight Disaster Suite

FSU-Florida State University
KNU-Taras Shevchenko National University of Kyiv

Methods and Testing

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Hack Disaster as a Systems Engineering Test Bed

ClearSight Requirements	Description
System Deployment	The system shall be deployable in under 24 hours for rapid disaster response.
Data Collection	The system shall capture high-resolution imagery and video of damaged structures.
Communication	The system shall enable real-time communication between aerial drones, ground-based drones, and the central command unit for coordinated assessments.
Damage Analysis	The system shall employ AI/ML algorithms to analyze collected data, identify damage types, and classify severity levels
Cost Estimation	The system shall generate cost estimates for repairs and reconstruction based on damage analysis and regional construction cost databases. TBD by the customer.
Scalability	The system shall be scalable to cover areas ranging from small urban neighborhoods to large-scale regional disasters.
Data Integration	The system shall integrate high-definition satellite imagery and other external data sources for initial assessments prior to drone deployment.

- **Systems Engineering Involvement:** Dr. David C. Gross, FSU Systems Engineering program professor challenged his MS students to participate in the event.
  - MSSE Students quickly took lead roles and set goals applying an SE approach
- **Identified key focus areas for success:**
  - Multidisciplinary system integration
  - Drone integration
  - AI-powered damage assessments
  - Cost estimation for recovery
  - User-Friendly Interface and Simulations
- **Highlighted SE Principles Implemented:**
  - Requirements Analysis and Formal Requirements Development
  - Concept of Operations (CONOP) & Operational View (OV-1) generation
  - Architecture & Integration -- High level system modeling/architecture to include Hardware, Software, AI, and Cost Modeling
  - Informal product Assessment of Alternatives (AoA)
  - Verification & Validation -- Ensuring system effectiveness with measurable success criteria and deliverable stakeholder/product visualizations.

ClearSight CONOPs

1. ClearCommand deploys as a command station
2. Satellite communication (SATCOM) established between ClearCommand and ClearPath
3. ClearPath deploys when communications link stable
4. ClearPath relays imagery via SATCOM to ClearCommand for analysis
5. Near-Real time analysis of imagery conducted with AI program aboard ClearCommand

IF AN INTERIOR NEEDS TO BE SURVEYED

- ClearPath Deploys PathFinder
- ClearPath Enters Relay Mode and establish communications with PathFinder while continuing to survey exterior
- PathFinder surveys interior
- ClearPath collects PathFinder after survey completion

6. Recall ClearPath to ClearCommand when survey is complete

System Architecture & Component Integration

- **COTS (Commercial Off-the-Shelf) Solutions**: A key goal was to leverage COTS solutions wherever possible, aiming for cost-efficiency, faster deployment, flexibility, scalability, and reduced development time.

Hardware Conceptualized and Specified:

- **ClearView SATCOM:** Provide imagery and communications for the Disaster Suite.
  - **Satellite Imagery (Various Commercial Providers):** High quality, cost effective.
  - **Communications Segment (Starlink)**: High Speed, low latency, and global availability.
- **ClearCommand Command and Control (Modified Shipping Container):** Control center for Disaster Suite operations.
- **ClearPath Aerial Drone (DJI FlyCart 30):** Aerial imaging, exterior damage assessments and logistics.
- **PathFinder Land Drone (SPUR):** Further exterior damage assessments and interior damage assessments.

Software Developed:

- **Automatic Damage Recognition Software:** AI-driven structural damage assessment and classification.
- **Mock System GUI:** Intuitive control & real-time assessment.
- **Drone System Simulation (Land + Air):** Verification and validation of Disaster Suite concepts/operations.
- **Cost Estimation Suite:** Probabilistic cost estimation
  - Computational analysis system
  - Monte Carlo Simulations

ClearPath Concept and Damage Analysis Operations

PathFinder COTS Solution

ClearCommand Modification Concept

ClearSight + PathFinder Deployment Concept

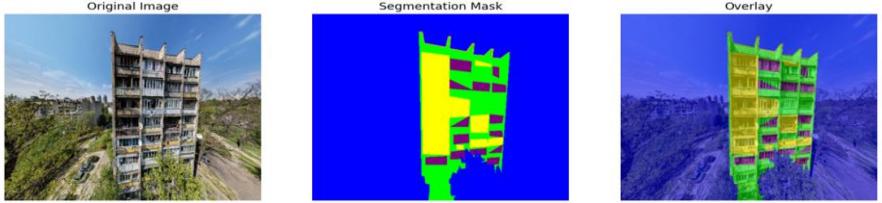
Verification & Validation

- Verification and Validation were achieved through AI-driven damage assessment and drone simulations, ensuring a robust proof of concept.

Analysis

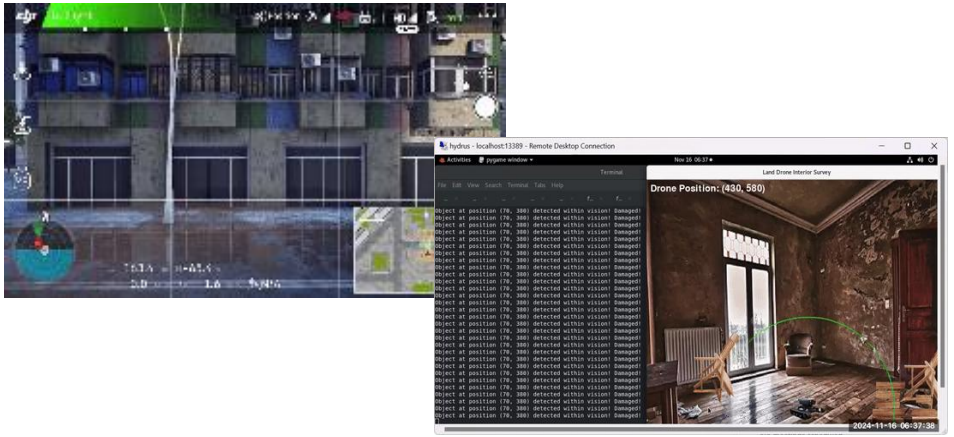
```
model_path = "/content/drive/MyDrive/Dataset_CVAI.zip (Unzipped Files)/Models/unet"
image1_path = "/content/drive/MyDrive/example_photo_cv.jpg"
image2_path = "/content/drive/MyDrive/example_cv_soledar.jpg"
model = torch.load(model_path)
model = model.to('cuda')
mask1 = predict_single_image(model, image1_path)
mask2 = predict_single_image(model, image2_path)
  # Show/save visualization with subplots
visualize_results(image1_path, mask1)
visualize_results(image2_path, mask2)
```

```
<ipython-input-25-2cfe273c75ae>:4: FutureWarning: You are using `torch.load` with `weights_only=False` (the current default value), which uses the default
  model = torch.load(model_path)
```



This series of images show semantic segmentation in action using a 2024 drone attack image from Odesa, and a destroyed building in the city of Soledar. The static picture shows a building from the validation set provided by the Hackathon Organizers

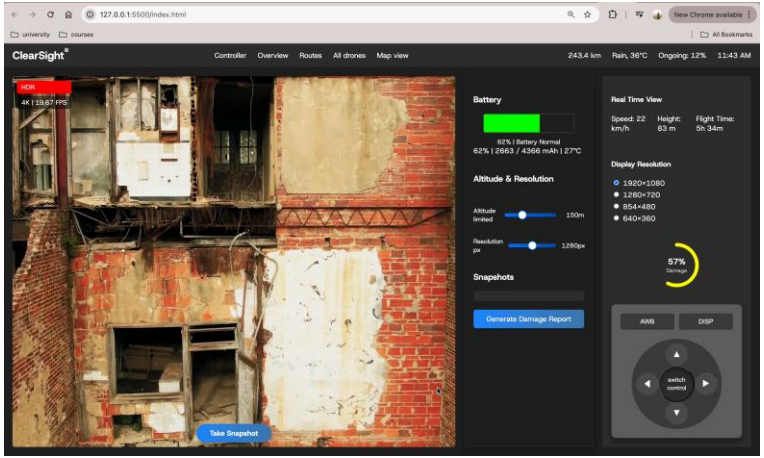
Simulation



The simulations above showcase testing simulations for aerial and land drone concepts developed during the exercise

Selected End User Products

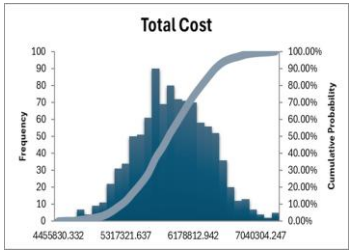
- **Graphical User Interface (GUI)**
  - A concept GUI was developed and is shown to showcase what a drone operator can expect to see when flying, with estimates of damage being calculated. This working GUI would require future integration into real world hardware subsystems and the data displayed would need to be assessed through stakeholder engagement.
- **Near-Real Time Cost Estimates**
  - A snip of the cost estimate spreadsheets and Monte Carlo simulations of total cost based on cost components is shown. These were delivered in working order to the stakeholders.



ClearSight Damage Assessment Cost Estimation

Inputs in column B drawn from AI imagery analysis

Component Name	Damaged Quantity	Unit Cost Rate ($
Site Preparation	200	21.69693141
Foundation	200	82.70510898
Structural Framing	450	84.63059092
Roofing	1000	42.93958903
Exterior Walls	500	107.6165919
Windows and Doors	50	1298.391525
Walls and Ceiling	2400	60.43486256
Flooring	3000	76.08395349
Stairs	99	4986.302007
Electrical	200	90.37875243



Results, Impacts and Takeaways

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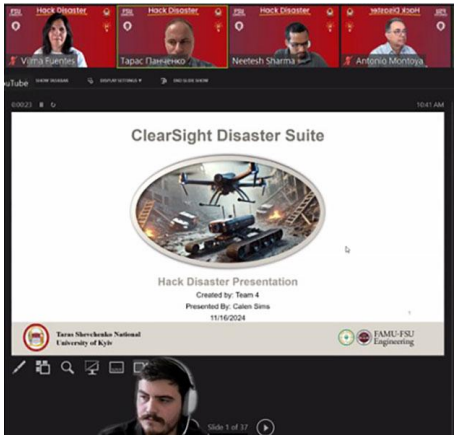
Results and SE Impact

- **Showcased an Effective Systems Engineering Approach**: The team successfully applied systems engineering principles rapidly to integrate various subsystems.
  - By breaking down complex challenges into manageable components, the systems engineering process facilitated the efficient development and integration of diverse solutions such as drones, AI analysis, and cost modeling tools.
- **Collaboration Across Disciplines**: The project demonstrated the power of systems engineering in uniting diverse technical disciplines.
  - This collaborative approach was further enhanced by the cross-cultural teamwork between American and Ukrainian students.
- **Rapid and Effective Presentation**: Through a disciplined systems engineering approach, the team presented and demonstrated a fully operational disaster assessment system within five days.
  - This achievement was a direct result of effective planning, resource management, and the application of proven engineering methods to meet tight deadlines.
  - **This is in stark contrast to most programmatic systems engineering efforts.**
- **Victory in the Hackathon Contest**: The project's success culminated in a contest victory, underscoring the effectiveness of the systems engineering processes.
  - The innovative, integrated solution outperformed others by meeting the competition's technical, operational and business requirements.



Implementing Rapid Systems Engineering

Strategy	Implementation Tactics
1. Accelerate with Agility	- Use iterative, fast-paced development cycles - Focus on early delivery of core functionality- Enable rapid adaptation to changing requirements
2. Leverage COTS Solutions	- Integrate Commercial-Off-The-Shelf (COTS) tech to reduce resources - Customize proven systems for mission-specific use
3. Use AI for Rapid Concepts	- Deploy AI to quickly create mockups, GUIs, dashboards, and visualizations - Use LLMs and generative tools to make ideas shareable and interactive
4. Engage Stakeholders Early	- Start with requirements analysis and CONOPs - Use AI-generated visuals and simulations for faster, more effective stakeholder alignment
5. Simulate Early & Often	- Run software and hardware simulations under realistic constraints - Validate decisions with tools like Monte Carlo risk models
6. Blend Disciplines	- Enable cross-functional teamwork across hardware, AI, UX, and operations - Use “divide and conquer” methods with strong integration architecture
7. Design for Deployment	- Ensure modularity, portability, and field-readiness - Build systems that operate in unstable or disconnected environments

(This is the slide you want a picture of!)

Please contact Calen Sims or the rest of the team for question on ideas and implementation!

Advancing the Field of Systems Engineering

Broader Applications to the field of Systems Engineering Include:

- **Advocating Rapid Systems Engineering**: Promote the adoption of agile and iterative systems engineering approaches to quickly adapt to changing requirements and constraints in high-pressure environments, ensuring timely solutions.
- **Bringing Together Multi-Disciplinary Teams**: Leverage systems engineering to unify experts from various technical disciplines
- **Fostering Cross-Cultural Collaboration**: Encourage diverse teams, like the combination of American and Ukrainian students, to collaborate, bringing unique perspectives.
- **Accelerating Innovation through Systems Integration**: Use systems engineering to drive innovation by integrating emerging technologies across different fields.
- **Enhancing Problem-Solving in Complex Environments**: Apply systems engineering principles to solve real-world challenges, such as disaster response.

Questions?

(Thank you again everyone!)

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