Design Resilience

Engineering Design Adaptability
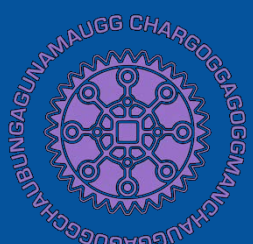### as modeled by
General Dynamics

**631A – Chargoggagoggmanchauggagoggchaubungagunamaugg**
Leo, Indiana

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Special Thanks to Joe Kennedy, Senior Distinguished Member, Technical Staff at GD

WHY CHOOSE GENERAL DYNAMICS?

General Dynamics (GD), the world's fifth-largest aerospace and defense company, provides mission critical capabilities to armed forces across multiple domains to meet a wide range of requirements. While GD's products revolve around

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weapons (with high levels of safety required) and military vehicles, what intrigued us were GD's developments in communications and cybersecurity. These **highly diverse domains** demand **highly resilient design processes**. We set out to understand how GD **rapidly responds** while also meeting customer needs for airworthy and safety critical solutions.

*Joe Kennedy of General Dynamics with Team 631A*

ENGINEERING DESIGN PROCESS (EDP)

Team 631A students learn to design and build a robot by collaboratively developing designs based on stated requirements according to a rigorous process as illustrated below.


General Dynamics Rapid Response Process
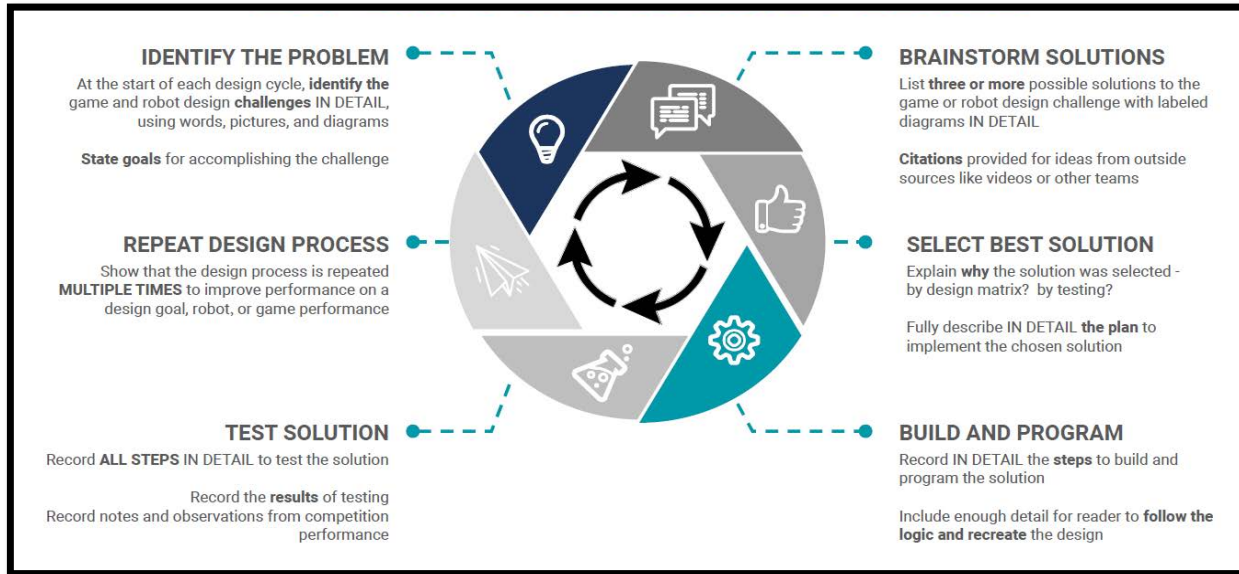
The EDP organizes the build into manageable steps to meet requirements, assure quality, optimize time, and develop exceptional solutions. We were intrigued to learn that GD incorporates an adaptable design process based on the needs of customers and their constraints.

GD's two design processes follow similar steps as 631A in achieving goals.
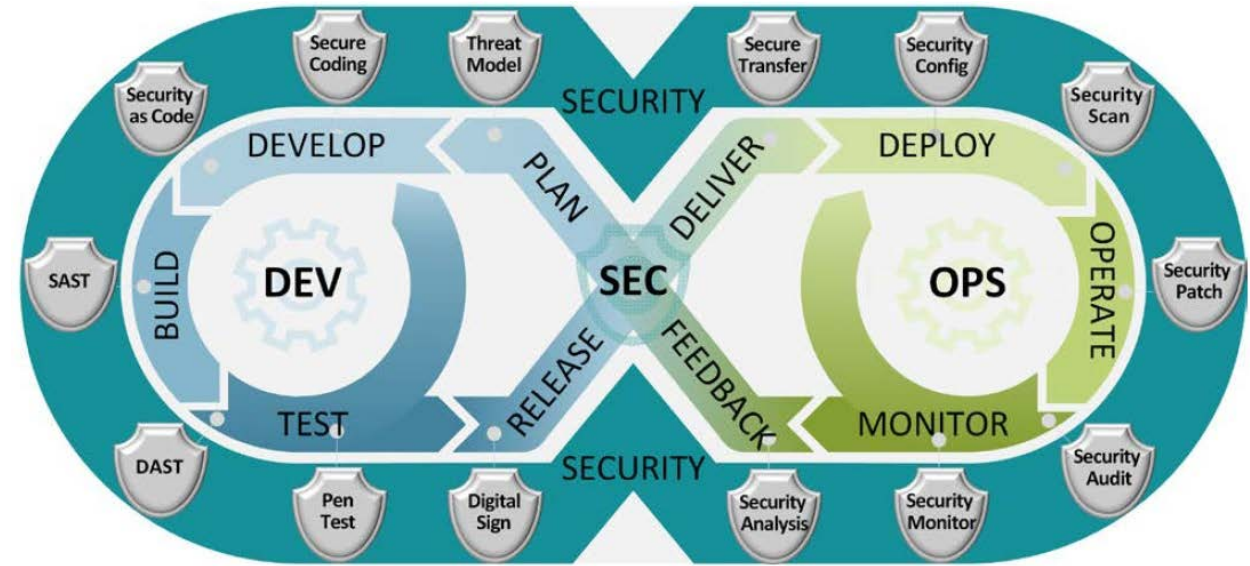
General Dynamics **Rapid Development Response** (RDR) called "DevSecOps" (Development, Security, Operations) decreases the time to completion; engineers must work fast to meet deadlines. The **High Safety Process** (HSP) uses the "System Development Life Cycle" (SDLC) in environments where a very high level of safety is required, e.g. munitions.

*General Dynamics Safe Response Process*
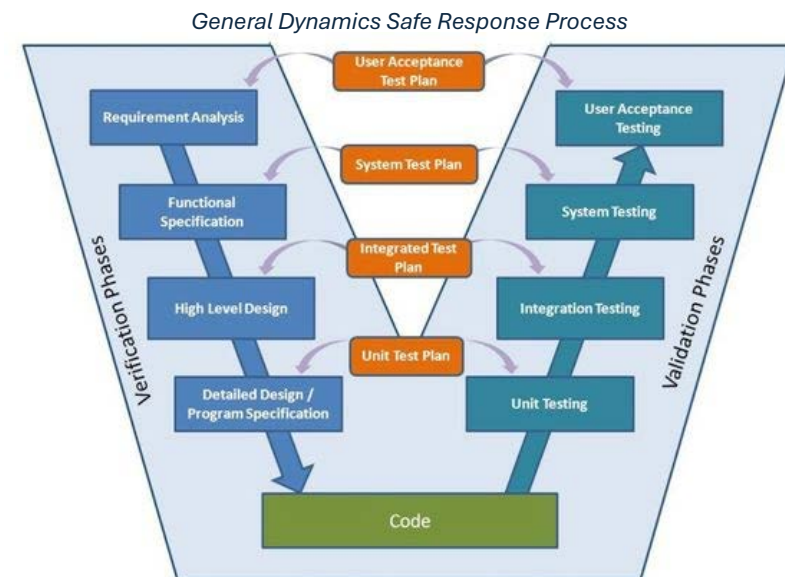
GD begins the design process in the same place as 631A: understanding the problem, the needs of a customer, or the constraints of a game.

Because GD is a defense contractor, its engineers' first step must include the creation of threat models and the development of countermeasures. GD must thoroughly understand customers' needs and portray those needs through the product.

System and time constraints, legality, resource limitations, specifications – both 631A and GD must consider these during the "identify" step. (The RDR model quickly moves to step 4.)

631A identifies game challenges for "Over Under."
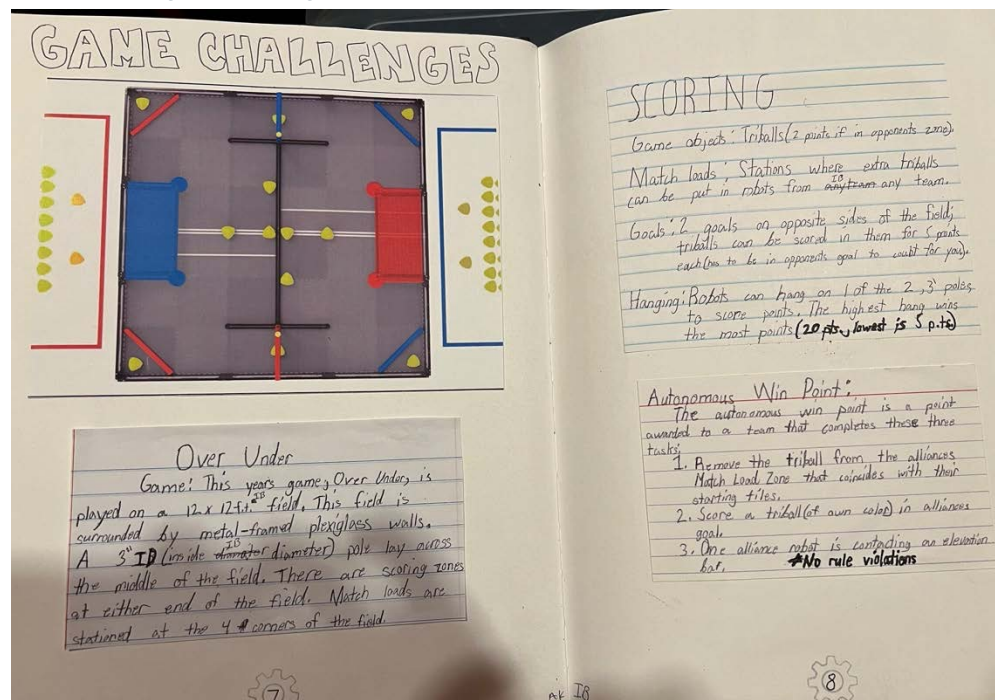
I D E N T I F Y

631A

Under the HSP, GD incorporates many of the same activities as 631A during its "brainstorm" step: (1) Functional Specifications, or design documents – like the "engineering notebook"; (2) High Level Design, where designs compete to meet technical and financial constraints – like the "Intake Designs" below; and (3) Program Specification, where ideas are broken into smaller modules – like the subsystems (drive train, shooter, intake, code) in 631A's process.

631A brainstorms various intake designs.
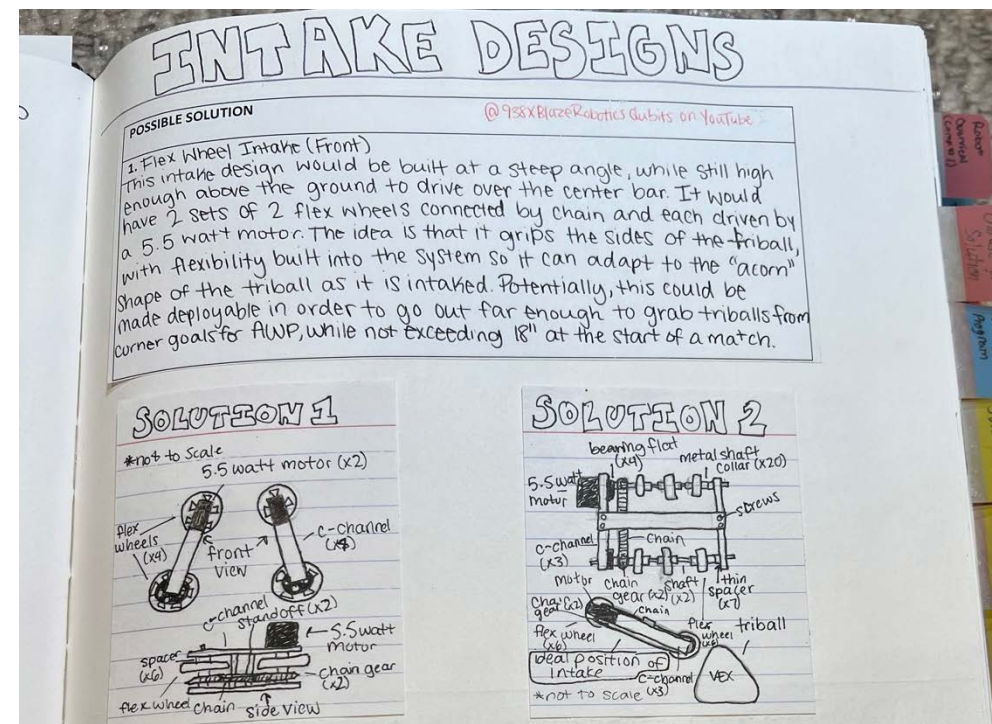
For both GD and VEX teams, brainstorming is essential in uncovering creative and innovative options for fulfilling the design requirements.

B R A I N S T O R M

631A

GD considers the technical and financial viability of options when choosing a design for the complete system, along with compatibility of subsystems.

631A's decision matrix for the base design.
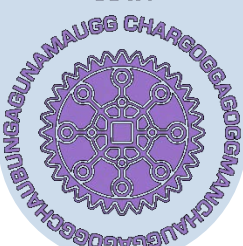
In the same way, 631A uses various decision matrices to score and choose a design. The example above illustrates the multiple requirements the team considered.

In the RDR and HSP, GD subdivides into smaller modules which must work seamlessly together. The build must also pass Static Application Security Tests (SAST), a cybersecurity test that identifies code and design flaws while offline, communicating them to the engineers.
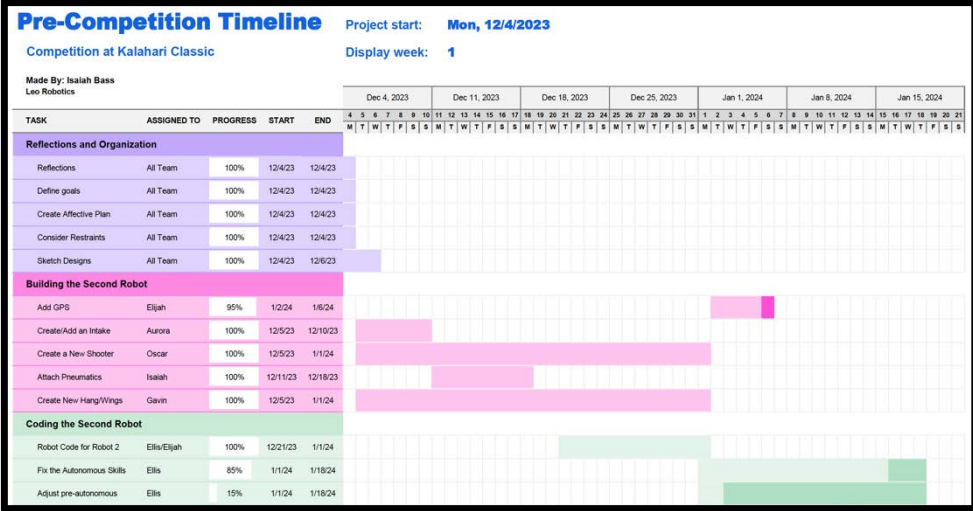
631A's first build robot:"FRAD."

631A also divides into subsystem groups. Throughout this process, all teams journal and communicate progress.
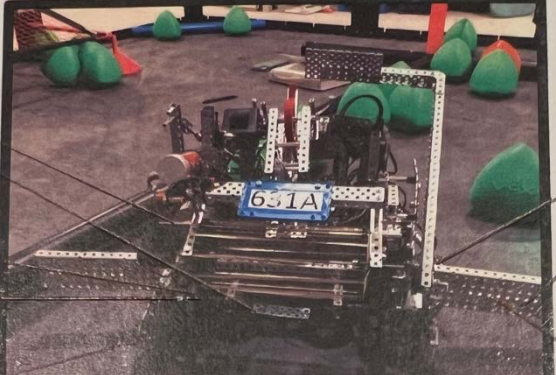
The team follows a rigid project schedule using a Gantt chart to determine completion timelines and identify shortfalls.

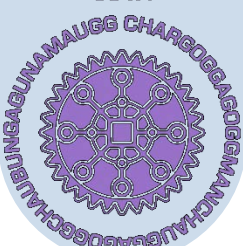*A Gantt chart keeps the Team on schedule.*

DevSecOps engineers complete a variety of tests to thoroughly check their product to ensure the reliability of the system, e.g. Dynamic Application Security Testing (DAST) and Penetration Testing (Pen test), both of which identify code flaws and vulnerabilities. In the HSP, testing involves modules, connectivity, the complete system, and approval.

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The prototype Advanced Reconnaissance Vehicle made by General Dynamics Land Systems.

631A follows a similar protocol, often testing subsystems 3 or more times before testing on the robot itself. Test results are recorded and referenced during this phase.

In both of GD's processes, these steps require repetition of earlier activities to improve (iterate) the design and build of the product: (1) deployment and monitoring, (2) user testing and acceptance, and (3) feedback. Example: Repetition is the primary work of GD's Ordnance & Tactical Systems (Canada), which tests and proofs product quality in modern ballistics laboratories.

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631A used feedback to make iterative improvements:

- Catapult → Linear Punch → **Faster, smaller Linear Punch**
- Plastic wedges → **Flex-Wheel wedges**
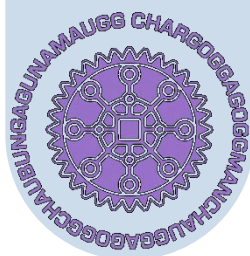- Rubber band intake → **Flex-Wheel intake**
- Wings → **Locking wings**

631A's final build robot: "KEVIN."
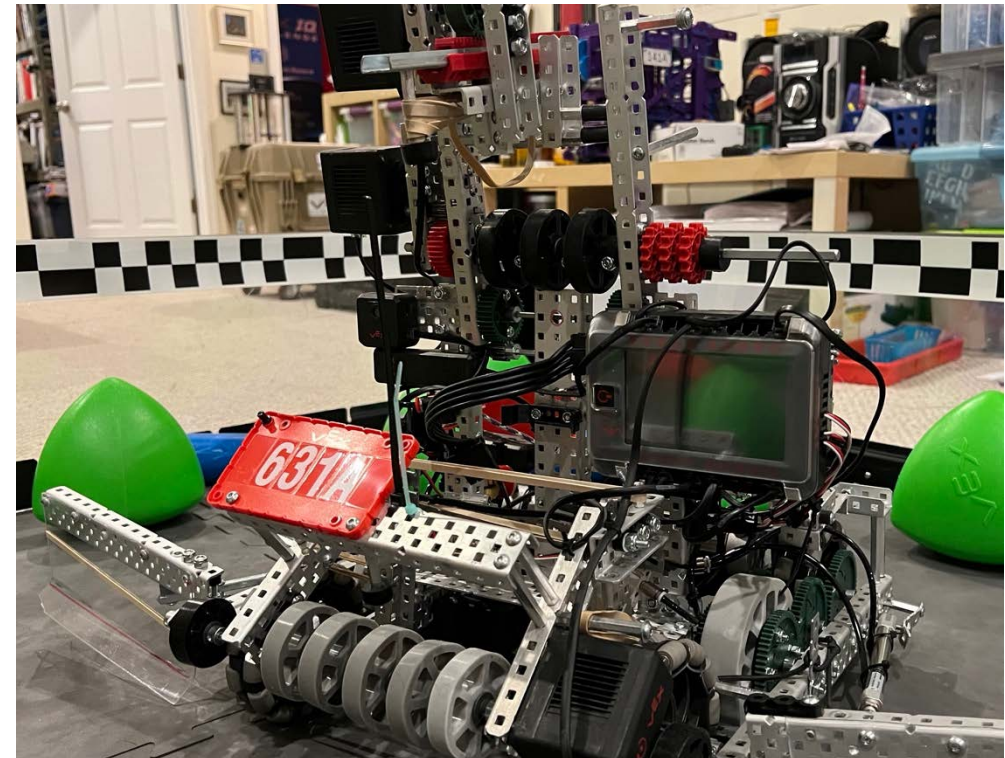
CAREER READINESS: THE KEY CONNECTIONS

General Dynamics has developed multiple design approaches that allow it to rapidly respond to worldwide challenges and opportunities. Similarly, VEX designs games that require students to use **critical thinking** and **resilience** to overcome multi-dimensional challenges.

GD engineers develop strategic security and business partnerships and **work as a team** in every step of the design process. To win, VEX students must observe and leverage healthy, collaborative relationships at every level of competition.

GD is rigorously committed to a **disciplined** supply chain and superior customer service. Likewise, VEX continues to prepare our team by requiring rigorous testing, careful observation, thorough documentation, and repeated effort.

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