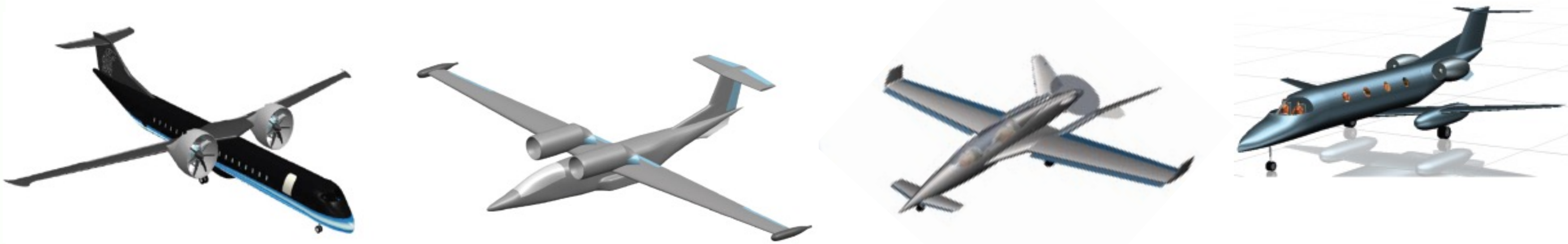
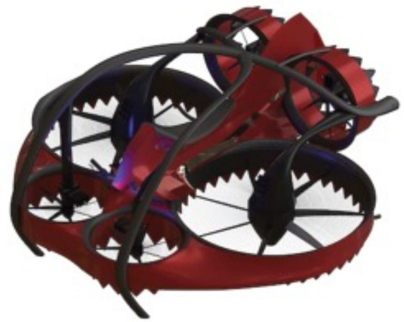
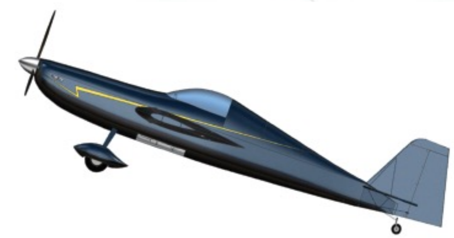
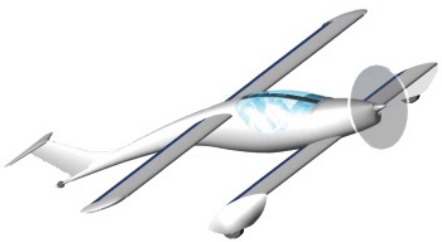
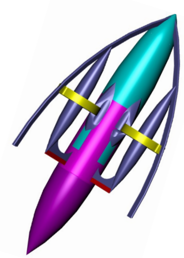
AE 521 Aerospace Design I

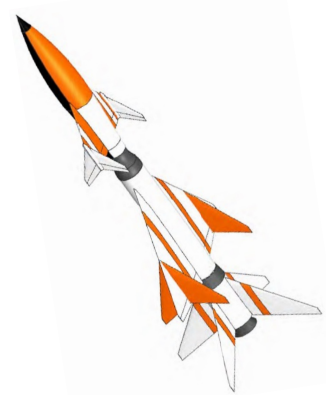












Dr. Ron Barrett-Gonzalez
Professor of Aerospace Engineering
The University of Kansas, Lawrence

Today's Schedule:

- Call Roll
- Service/Outreach Sign-Ups:

  Mon. 10/23 Eisenhower Middle School, Abilene

  Mon. 10/30 Wamego Middle School

  Sat. 12/2 Flint Hills Discovery Center, Manhattan

  Sat. 12/9 Flint Hills Discovery Center, Manhattan

  ? Farley Elementary visit to KU Campus
- Competitions
- Small Report 5
- Hyperbook

AEROSPACE JEOPARDY!

Fall 2023 Outreach Activities Driver/Rider signups

	Mon. 10/23	Mon. 10/30	Sat. 12/2	Sat. 12/9
Ativie,Joseph			x	
Bailey,Lucy M				
Barland,Jack A	x		x	
Bonham,Maggie E		x		
Braaten,Niels C		x		
Caulfield,Camden Lee				
Coppens,Ryan				
Dargahi,Alex			x	
Denault,Carson Robert		x		
Deng,Keyu			x	
Dillon,Peter				
Dodge,Andrew				
Dunlay,Joshua P	x			
Dutta,Sap				
Foster,Dean C	x		x	x
Gillies,Gunnar			x	x
Goudschaal-Frazier,Gracyn Jane				
Guzman,Jonathan Alan		x		
Harder,Samuel A			x	x
Heide,Rhett Gile	x		x	
Horst,Evelyn			x	
Hunt,Wesley Afra	x			
Junnare,Nupoor	x	x		
Keathley,Liliana Gabriel				
King,Kathryn M				
Kuligowski,Payton M			x	x
Larsen,Isaac		x		x

	Mon. 10/23	Mon. 10/30	Sat. 12/2	Sat. 12/9
Linthavong,Cherry			x	
Lofland,Chris C	x	x		
Marshall,Jeb O	x		x	x
Mays,Benjamin S		x		
Mcmichael,Barrett			x	x
Mcnulty,Jack B		x		
Mistretta,Anthony J		x		
Olson,Kadin Lee	x		x	
Platt,Charlie M		x		
Poznanski,Joshua	x	x	x	x
Reida,Reanne N			x	x
Reidy,Macoy M		x	x	
Relan,Jennifer	x	x	x	x
Richardson,Jake	x		x	x
Russell,Lucas S	x		x	x
Schneider,Cade W	x		x	x
Shah,Dhairya	x	x		
Sullivan,Tim Michael				
Sutton,Joshua T				x
Svoboda,Benjamin C		x		
Thorson,Johnathan A		x		
To,Hoang Minh			x	
Torok,Jackson P				x
Torres Leon,Hector	x		x	
Waggoner,Alex				x
Wall,James Edgar			x	
Wegiel,Jeremy L				

UPCOMING AEROSPACE JEOPARDY TOPICS

Game 3	Commercial Transports	General Aviation	Fighters	Aircraft Designers	Aerodynamics	Stability & Control
Game 4	Amphibians	Homebuilts	Interceptors	Politicians	Performance	Materials & Processes
Game 5	Bombers	Autogyros	Lighter than Air	Military Leaders	Propulsion	Structures
Game 6	Before WWI	Naval Aviation	Transport Helicopters	Aerospace Professors	Strength of Materials	Fluid Mechanics
Game 7	Gliders	X-Planes	Launch Vehicles	Astronauts	Weight Sizing	Conversions
Game 8	Cold War	Tactical Missiles	Commercial Transports	First Flights	Stability and Control	Piston Engines
Game 9	Russian Aerospace	European Aerospace	Canadian Aerospace	Doctrines & Agreements	Rocket Engines	Jet Engines
Game 10	Experimental Airplanes	Experimental Rotorcraft	Attack Airplanes	Corporate Leaders	Wing Sizing	Configurations
Game 11	Business Transports	Prehistoric Aerospace Devices & Lore	VTOL Aircraft	KU Professors	Stability and Control	Exoatmospherics
Game 12	NASA Trivia	Surface-to-Air Missiles	Unusual Weapons	Aerospace Laws	The Atmosphere	Materials & Processes
Game 13	Military Transports	Pioneer Years	Low Observables Aircraft	Combat Pilots	Supersonic Aerodynamics	Aircraft Configurations
Game 14	Aerospace Economics	Strategic Missiles	Hard-Launched Munitions	Aerospace Museums	Guidance, Navigation & Control	Aerospace Safety Practices
Game 15	Urban Air Mobility	Flying Toys and Sports	Air Crashes and Fatalities	KU & KUAE History	Design Practices	Circuits and Instrumentation
Game 16	Record Setters	Failed Designs	Aerospace Scandals & Cover-Ups	Dirty Politics	Design Practices	Finite Element Methods

Competitions

American Institute of Aeronautics & Astronautics (AIAA):

- Undergraduate Team: Heavy Lift Mobility Platform
- Undergraduate Individual: Stratospheric Payload Delivery
- Graduate Team: Electric Training Sailplane
- Graduate Missile: Rapid Reaction Satellite Launcher

Vertical Flight Society (VFS):

- Multi-Mission Modular UAS for Disaster Relief

Competitions

American Institute of Aeronautics & Astronautics (AIAA):

- Undergraduate Team: Heavy Lift Mobility Platform
- Undergraduate Individual: Stratospheric Payload Delivery
- Graduate Team: Electric Training Sailplane
- Graduate Missile: Rapid Reaction Satellite Launcher

Vertical Flight Society (VFS):

- Multi-Mission Modular UAS for Disaster Relief

You do not have to compete, but...

You must choose/develop a mission spec. and profile of professional caliber from previous competitions

Think about which one(s) you want to do…

Student	AIAA UGTeam Heavy Lift	AIAA UG Indiv. Strato Payload	AIAA GTeam Electric Sailplane	AIAA Missile	VFS Disaster Relief UAS	Other	Graduation
Ativie,Joseph							
Bailey,Lucy M							
Barland,Jack A							
Bonham,Maggie E							
Braaten,Niels C							
Caulfield,Camden Lee							
Coppens,Ryan							
Dargahi,Alex							
Denault,Carson Robert							
Deng,Keyu							
Dillon,Peter							
Dodge,Andrew							
Dunlay,Joshua P							
Dutta,Sap							
Foster,Dean C							
Gillies,Gunnar							
Goudschaal-Frazier,Gracyn Jane							
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Horst,Evelyn							
Hunt,Wesley Afra							
Junnare,Nupoor							
Keathley,Liliana Gabriel							
King,Kathryn M							
Kuligowski,Payton M							
Larsen,Isaac							

Think about which one(s) you want to do…

Student	AIAA UGTeam Heavy Lift	AIAA UG Indiv. Strato Payload	AIAA GTeam Electric Sailplane	AIAA Missile	VFS Disaster Relief UAS	Other	Graduation
Linthavong,Cherry							
Lofland,Chris C							
Marshall,Jeb O							
Mays,Benjamin S							
Mcmichael,Barrett							
Mcnulty,Jack B							
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Torok,Jackson P							
Torres Leon,Hector							
Waggoner,Alex							
Wall,James Edgar							
Wegiel,Jeremy L							

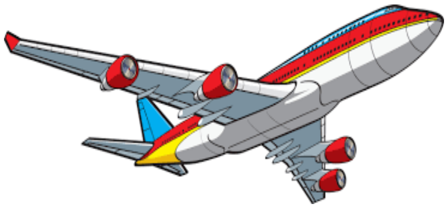
Small Report 5

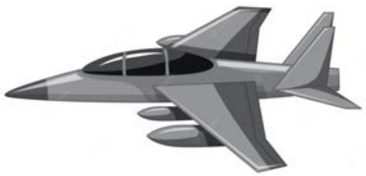
1. Choose a Competition from the list of AIAA and VFS Competitions
2. Develop an Abbreviated Operating Statement (AOS) for the chosen competition and Generate a Concept of Operations (ConOps)
3. Generate the Mission Specification and Profile

Aircraft Design Process

Where it all begins:

The People, Laws, Rules & Regulations





Civil Aerospace Systems

FAA:

Governs flight in "navigable airspace"

Military Aerospace Systems

DoD:

Governs flight in military airspace & of military systems

Aircraft Design Process

Civil Aerospace Systems

Airplane Type	Passenger Limit	Weight Limit	Regulations
Ultralight	1	155/254lb	Ultralight FAR 103
Homebuilt	none	none	Experimental FAR 21
Light Sport Aircraft	1	1320lb	ASTM Consensus Stds
Propeller & Agricultural planes, Flying Boats, Supersonic	< 9	12,500lb	Normal Category FAR 23,
Twin Prop, Regional Turboprop, Transport Jets, Flying Boats, Supersonic	< 19	19,000lb	Commuter Category: FAR 23
Business Jets, Regional Turboprops, Transport Jets, Flying Boats, Supersonic Cruise Airplanes	> 19	none	FAR 25
Military Trainers, Fighters, Attack Aircraft, Military Patrol, Bomb & Transport Aircraft	none	none	Military

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - Army

Section IV - Functions of the United States Army

The United States Army includes land combat and service forces and such aviation and water transport as may be organic therein. It is organized, trained, and equipped primarily for prompt and sustained combat operations on land. Of the three major Services, the Army has primary interest in all operations on land, except in those operations otherwise assigned herein.

A. Primary Functions

1. To organize, train, and equip Army forces for the conduct of prompt and sustained combat operations on land. Specifically:

a. To defeat enemy land forces.

b. To seize, occupy, and defend land areas.

2. To organize, train, and equip Army antiaircraft artillery units.

3. To organize and equip, in coordination with the other Services, and to provide Army forces for joint amphibious and airborne operations, and to provide for the training of such forces in accordance with policies and doctrines of the Joint Chiefs of Staff.

4. To develop, in coordination with the other Services, tactics, technique, and equipment of interest to the Army for amphibious operations and not provided for in Section V, paragraph A 4 and paragraph A 11 c.

Aircraft Design Process

Military Aerospace Systems

1948 Key West Agreement - Army

5. To provide an organization capable of furnishing adequate, timely, and reliable intelligence for the Army.

6. To provide Army forces as required for the defense of the United States against air attack, in accordance with joint doctrines and procedures approved by the Joint Chiefs of Staff.

7. To provide forces, as directed by proper authority, for occupation of territories abroad, to include initial establishment of military government pending transfer of this responsibility to other authority.

8. To develop, in coordination with the Navy, the Air Force, and the Marine Corps, the doctrines, procedures, and equipment employed by Army and Marine forces in airborne operations. The Army shall have primary interest in the development of those airborne doctrines, procedures and equipment which are of common interest to the Army and the Marine Corps.

9. To formulate doctrines and procedures for the organization, equipping, training, and employment of forces operating on land, at division level and above, including division corps, army, and general reserve troops, except that the formulation of doctrines and procedures for the organization, equipping, training, and employment of Marine Corps units for amphibious operations shall be a function of the Department of the Navy, coordinating as required by paragraph A 11 c, Section V.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - Army

10. To provide support, as directed by higher authority, for the following activities.

a. The administration and operation of the Panama Canal.

b. River and harbor projects in the United States, its territories, and possessions.

c. Certain other civil activities prescribed by law.

B. Collateral Functions. The forces developed and trained to perform the primary functions set forth above shall be employed to support and supplement the other Services in carrying out their primary functions, where and whenever such participation will result in increased effectiveness and will contribute to the accomplishment of the over-all military objectives. The Joint Chiefs of Staff member of the Service having primary responsibility for a function shall be the agent of the Joint Chiefs of Staff to present to that body the requirements for and plans for the employment of all forces to carry out the function. He shall also be responsible for presenting to the Joint Chiefs of Staff for final decision any disagreement within the field of his primary responsibility which has not been resolved. This shall not be construed to prevent any member of the Joint Chiefs of Staff from presenting unilaterally any issue of disagreement with another Service. Certain specific collateral functions of the Army are listed below:

1. To interdict enemy sea and air power and communications through operations on or from land.

2. To provide forces and equipment for and to conduct controlled mine field operations.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - Navy

Section V - Functions of the United States Navy and Marine Corps

Within the Department of the Navy, assigned forces include the entire operating forces of the United States Navy, including naval aviation, and the United States Marine Corps. These forces are organized, trained, and equipped primarily for prompt and sustained combat operations at sea, and for air and land operations incident thereto. Of the three major Services, the Navy has primary interest in all operations at sea, except in those operations otherwise assigned herein.

A. Primary Functions

1. To organize, train, and equip Navy and Marine Forces for the conduct of prompt and sustained combat operations at sea, including operations of sea-based aircraft and their land-based naval air components. Specifically:

a. To seek out and destroy enemy naval forces and to suppress enemy sea commerce.

b. To gain and maintain general sea supremacy.

c. To control vital sea areas and to protect vital sea lines of communication.

d. To establish and maintain local superiority (including air) in an area of naval operations.

e. To seize and defend advanced naval bases and to conduct such land operations as may be essential to the prosecution of a naval campaign.

Aircraft Design Process

Military Aerospace Systems

1948 Key West Agreement - Navy

2. To conduct air operations as necessary for the accomplishment of objectives in a naval campaign.

3. To organize and equip, in coordination with the other Services, and to provide Naval forces, including Naval close air support forces, for the conduct of joint amphibious operations, and to be responsible for the amphibious training of all forces as assigned for joint amphibious operations in accordance with the policies and doctrines of the Joint Chiefs of Staff.

4. To develop, in coordination with the other Services, the doctrines, procedures, and equipment of naval forces for amphibious operations, and the doctrines and procedures for joint amphibious operations.

5. To furnish adequate, timely, and reliable intelligence for the Navy and Marine Corps.

6. To be responsible for naval reconnaissance, antisubmarine warfare, the protection of shipping, and for mine laying, including the air aspects thereof.

7. To provide air transport essential for naval operations.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - Navy

8. To provide sea-based air defense and the sea-based means for coordinating control for defense against air attack, coordinating with the other Services in matters of joint concern.

9. To provide naval (including naval air) forces as required for the defense of the United States against air attack, in accordance with joint doctrines and procedures approved by the Joint Chiefs of Staff.

10. To furnish aerial photography as necessary for naval and Marine Corps operations.

11. To maintain the United States Marine Corps, which shall include land combat and service forces and such aviation as may be organic therein. Its specific functions are:

a. To provide Fleet Marine Forces of combined arms, together with supporting air components, for service with the Fleet in the seizure or defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign. These functions do not contemplate the creation of a second land army.

b. To provide detachments and organizations for service on armed vessels of the Navy, and security detachments for the protection of naval property at naval stations and bases.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - Navy

c. To develop, in coordination with the Army, the Navy, and the Air Force, the tactics, technique, and equipment employed by landing forces in amphibious operations. The Marine Corps shall have primary interest in the development of those landing force tactics, technique, and equipment which are of common interest to the Army and the Marine Corps.

d. To train and equip, as required, Marine Forces for airborne operations, in coordination with the Army, the Navy, and the Air Force in accordance with policies and doctrines of the Joint Chiefs of Staff.

e. To develop, in coordination with the Army, the Navy, and the Air Force, doctrines, procedures, and equipment of interest to the Marine Corps for airborne operations and not provided for in Section IV, paragraph A 8.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - Navy

B. Collateral Functions. The forces developed and trained to perform the primary functions set forth above shall be employed to support and supplement the other Services in carrying out their primary functions, where and whenever such participation will result in increased effectiveness and will contribute to the accomplishment of the over-all military objectives. The Joint Chiefs of Staff member of the Service having primary responsibility for a function shall be the agent of the Joint Chiefs of Staff to present to that body the requirements for and plans for the employment of all forces to carry out the function. He shall also be responsible for presenting to the Joint Chiefs of Staff for final decision any disagreement within the field of his primary responsibility which has not been resolved. This shall not be construed to prevent any member of the Joint Chiefs of Staff from presenting unilaterally any issue of disagreement with another Service. Certain specific collateral functions of the Navy and Marine Corps are listed below:

1. To interdict enemy land and air power and communications through operation at sea.

2. To conduct close air support for land operations.

3. To furnish aerial photography for cartographic purposes.

4. To be prepared to participate in the over-all air effort as directed by the Joint Chiefs of Staff.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - USAF

Section VI - Functions of the United States Air Force

The United States Air Force includes air combat and service forces. It is organized, trained, and equipped primarily for prompt and sustained combat operations in the air. Of the three major Services, the Air Force has primary interest in all operations in the air, except in those operations otherwise assigned herein.

A. Primary Functions

1. To organize, train and equip Air Force forces for the conduct of prompt and sustained combat operations in the air. Specifically:

a. To be responsible for defense of the United States against air attack in accordance with the policies and procedures of the Joint Chiefs of Staff.

b. To gain and maintain general air supremacy.

c. To defeat enemy air forces.

d. To control vital air areas.

e. To establish local air superiority except as otherwise assigned herein.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - USAF

2. To formulate joint doctrines and procedures, in coordination with the other Services, for the defense of the United States against air attack, and to provide the Air Force units, facilities, and equipment required therefor.

3. To be responsible for strategic air warfare.

4. To organize and equip Air Force forces for joint amphibious and airborne operations, in coordination with the other Services, and to provide for their training in accordance with policies and doctrines of the Joint Chiefs of Staff.

5. To furnish close combat and logistical air support to the Army, to include air lift, support, and resupply of airborne operations, aerial photography, tactical reconnaissance, and interdiction of enemy land power and communications.

6. To provide air transport for the Armed Forces except as otherwise assigned.

7. To provide Air Force forces for land-based air defense, coordinating with the other Services in matters of joint concern.

8. To develop, in coordination with the other Services, doctrines, procedures, and equipment for air defense from land areas, including the continental United States.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - USAF

9. To provide an organization capable of furnishing adequate, timely, and reliable intelligence for the Air Force.

10. To furnish aerial photography for cartographic purposes.

11. To develop, in coordination with the other Services, tactics, technique, and equipment of interest to the Air Force for amphibious operations and not provided for in Section V, paragraph A 4 and paragraph A 11 c.

12. To develop, in coordination with the other Services, doctrines, procedures, and equipment employed by Air Force forces in airborne operations.

Aircraft Design Process

Military Aerospace Systems 1948 Key West Agreement - USAF

B. Collateral Functions. The forces developed and trained to perform the primary functions set forth above shall be employed to support and supplement the other Services in carrying out their primary functions, where and whenever such participation will result in increased effectiveness and will contribute to the accomplishment of the over-all military objectives. The Joint Chiefs of Staff member of the Service having primary responsibility for a function shall be the agent of the Joint Chiefs of Staff to present to that body the requirements for and plans for the employment of all forces to carry out the function. He shall also be responsible for presenting to the Joint Chiefs of Staff for final decision any disagreement within the field of his primary responsibility which has not been resolved. This shall not be construed to prevent any member of the Joint Chiefs of Staff from presenting unilaterally any issue of disagreement with another Service. Certain specific collateral functions of the Air Force are listed below:

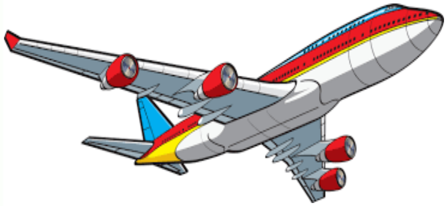
1. To interdict enemy sea power through air operations.

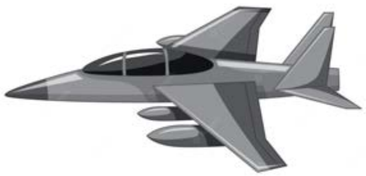
2. To conduct antisubmarine warfare and to protect shipping.

3. To conduct aerial minelaying operations.

Aircraft Design Process

Overall Directions





Civil:

↓

Basic Operating Statements

↓

Mission Statement

↓

Operating Documents

Military:

↓

Basic Operating Statements

↓

Mission Statement

↓

Operating Documents

Aircraft Design Process

Civil Corporations

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

Example:

FAA: "Safety is our passion"

Aircraft Design Process

Military

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

Example -- Army:

AN ARMY OF ONE
U.S. ARMY

U.S. ARMY®
ARMY STRONG.℠

ARMY.
BE ALL YOU CAN BE.

Aircraft Design Process

Military

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

Example -- Navy:

Aircraft Design Process

Military

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

Example -- USAF:

Aircraft Design Process

Civil Corporations

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

Example:

Pratt and Whitney: "Reliable Engines"

GO BEYOND | PRODUCTS & SERVICES | NEWSROOM | COMPANY | CAREERS | SUPPORT | CUSTOMER LOGIN

Pratt & Whitney GTF™ Engines Achieve World-class Reliability

EAST HARTFORD, Conn., December 18, 2020 - Pratt & Whitney, a division of Raytheon Technologies Corp. (NYSE: RTX), today announced that GTF engines powering the A320neo family have achieved a world-class engine dispatch reliability rate of 99.98%. The GTF engine powers more than 900 aircraft across nearly 50 airlines and three aircraft families: Airbus A320neo, Airbus A220 and Embraer E-Jets E2. GTF engines have saved more than 400 million gallons of fuel and over 3.8 million metric tonnes of carbon emissions since they entered service in 2016.

"Thanks to upgrades completed in close coordination with our customers in 2020, GTF engines for the A320neo family are now delivering industry-leading reliability," said Carroll Lane, president of Commercial Engines at Pratt & Whitney. "When you combine this with our best-in-class fuel efficiency and low carbon emissions, it's easy to see why GTF-powered fleets have seen high utilization as the industry begins to recover."

Aircraft Design Process

Civil Corporations

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

Example:

Airbus: "We make it fly"

We Make It Fly

From Startup to Aerospace Giant: The Airbus Story

Welcome to the Airbus Podcast, 'We Make It Fly'.Here you will find conversations on everything Airbus - what the company is currently up to across its several divisions, its plans for an innovative & sustainable futu ...More

Aircraft Design Process

Civil Corporations

Abbreviated Operating Statements

- Just a few words
- Describes overall corporate direction

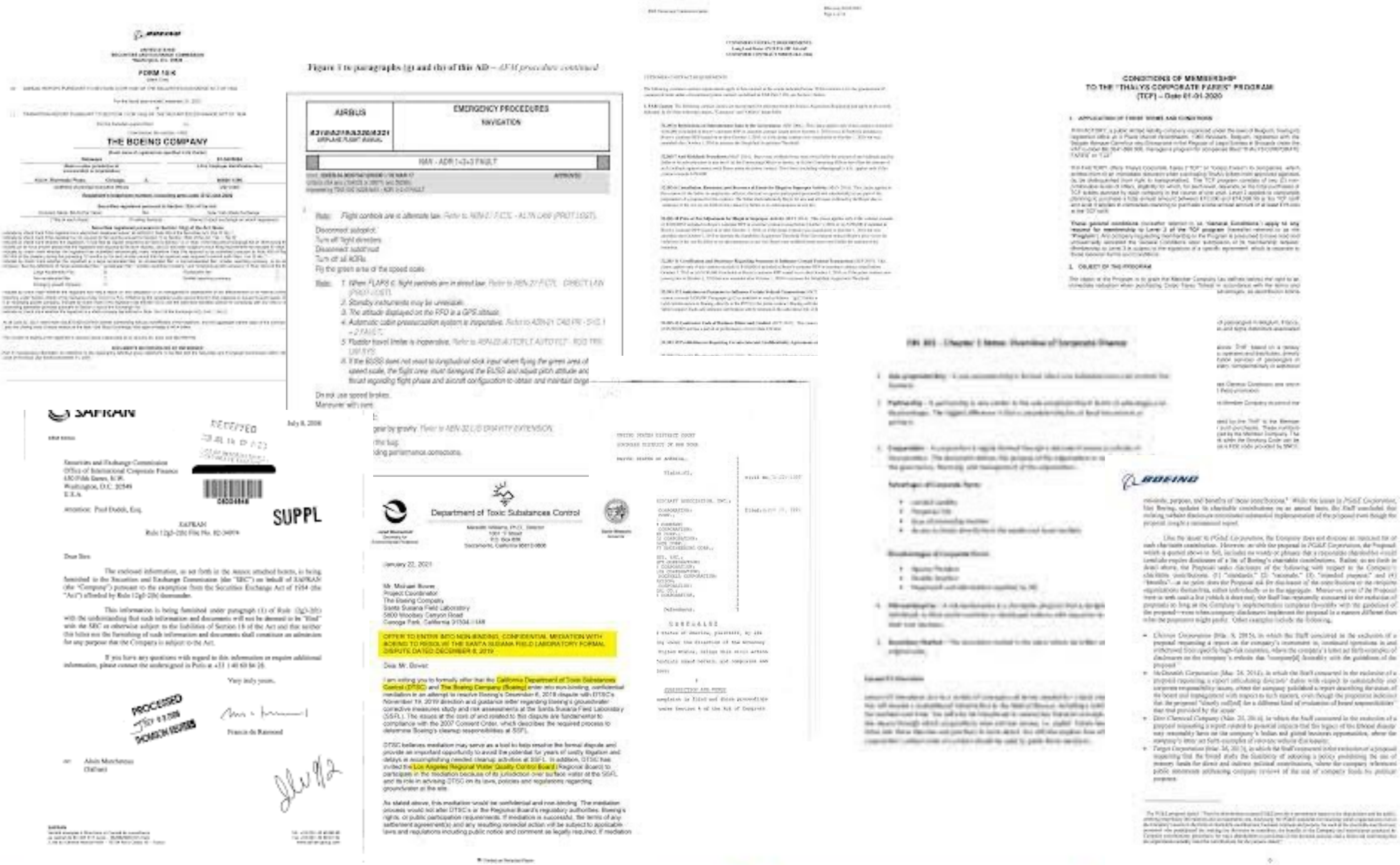
Example:

Boeing: "Build something better"

Aircraft Design Process

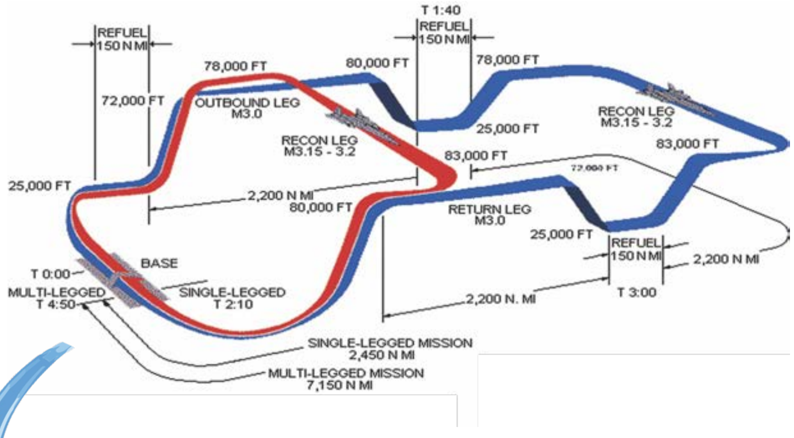
Operating Documents

Countless thousands of pages...



Aircraft Design Process

1. Military Leaders, Business Team, & Management Assess Need for a New Aerospace Vehicle or System



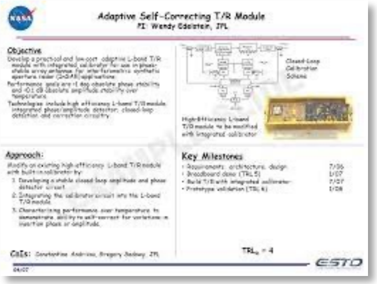
2. Mission Specification and Profile Generated

3. Engineering Teams Develop Designs to Meet Mission

4. Designs Synthesized

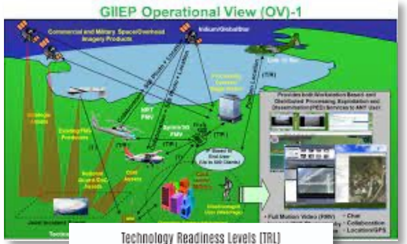
Aerospace System Management Tools:

1. Heilmeir's Catechisms



2. Quad Charts

3. Concept of Technology (ConTech)



4. Concept of Operations (ConOps)

5. Technology Readiness Level (TRL)

6. Systems Engineering (SE)

Technology, System and Vehicle Descriptions

Heilmeier's Catechism

- What are you trying to do? Articulate your objectives using absolutely no jargon. What is the problem? Why is it hard?
- How is it done today, and what are the limits of current practice?
- What's new in your approach and why do you think it will be successful?
- Who cares?
- If you're successful, what difference will it make? What impact will success have? How will it be measured?
- What are the risks and the payoffs?
- How much will it cost?
- How long will it take?
- What are the midterm and final "exams" to check for success? How will progress be measured?

Ultra-High Sensitivity Acoustic Vector Sensor

What are we trying to do?
Develop an acoustic vector sensor with an order of magnitude higher sensitity levels for effective acoustic radar, UAV sense & avoid, countersniper, quiet UAV sensing etc...

How does this currently get done?
Doppler shift & conventional ACS techniques

Who does it now? MicroFlown, ShotSpotter, Boomerang

What limits present approaches? Low-Rn aerodynamics effects on filaments

What is new about our approach? Dynamic filament sweeping sheds laminar boundary layer & increases sensing sweep area

Why, at this time, can our approach succeed? New method just proven in the lab less than 4 mos. ago, provisional patent filed just weeks ago

What difference does our approach offer? Order of magnitude greater AVS sensitivity, impervious to atmospheric foulants

What are the "mid-term" and "final exams?" i. Anechoic Test ii. Flight Test

How much will our approach cost? ~$1M over 3 yrs for flying POC

2120 Learned Hall, The University of Kansas, Lawrence, Kansas 66044 (785) 864-2226 barrettr@ku.edu

Quad Charts

Adaptive Self-Correcting T/R Module

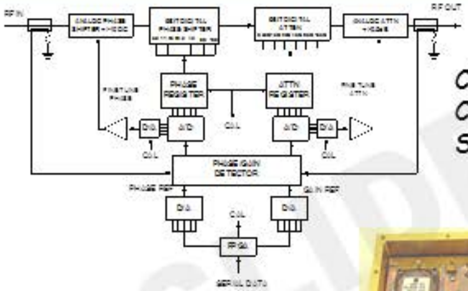
PI: Wendy Edelstein, JPL

Objective

Develop a practical and low cost adaptive L-band T/R module with integrated calibrator for use in phase-stable array antennas for interferometric synthetic aperture radar (InSAR) applications.

Performance goals are <1 deg absolute phase stability and <0.1 dB absolute amplitude stability over temperature.

Technologies include high efficiency L-band T/R module; integrated phase/amplitude detector; closed-loop detection and correction circuitry.



Closed-Loop Calibration Scheme

High-Efficiency L-band T/R module to be modified with integrated calibrator

Approach:

Modify an existing high-efficiency L-band T/R module with built-in calibrator by:

1. Developing a stable closed-loop amplitude and phase detector circuit.
2. Integrating the calibrator circuit into the L-band T/R module.
3. Characterizing performance over temperature to demonstrate ability to self-correct for variations in insertion phase or amplitude.

CoIs: Constantine Andricos, Gregory Sadowy, JPL

Key Milestones

• Requirements, architecture, design	7/06
• Breadboard demo (TRL 5)	1/07
• Build T/R with integrated calibrator	7/07
• Prototype validation (TRL 6)	1/08

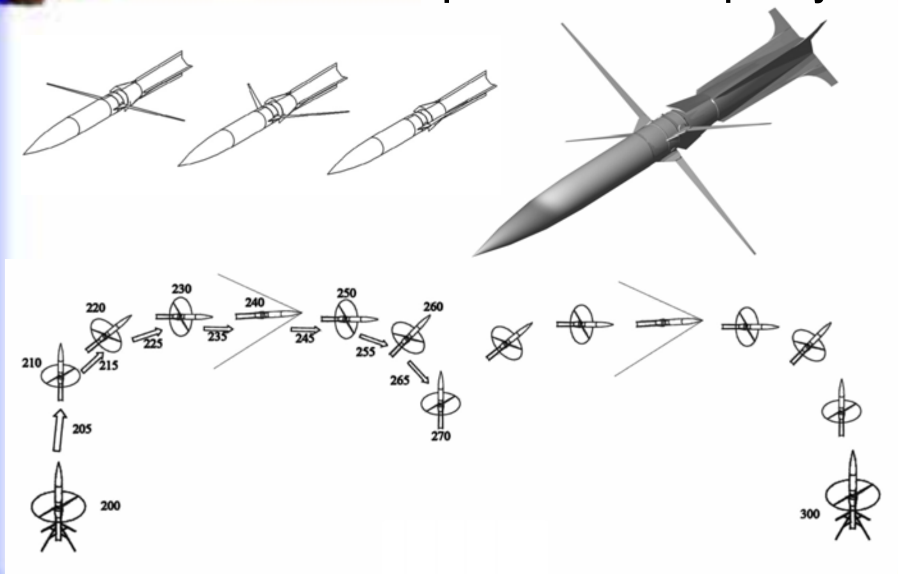
$TRL_{in} = 4$

04/07

ESTO Earth Science Technology Office

Supersonic Hovering Aerial Vehicle (SHAV) for Counterpiracy

Hover – Transonic – Supersonic UAV/Weapon System

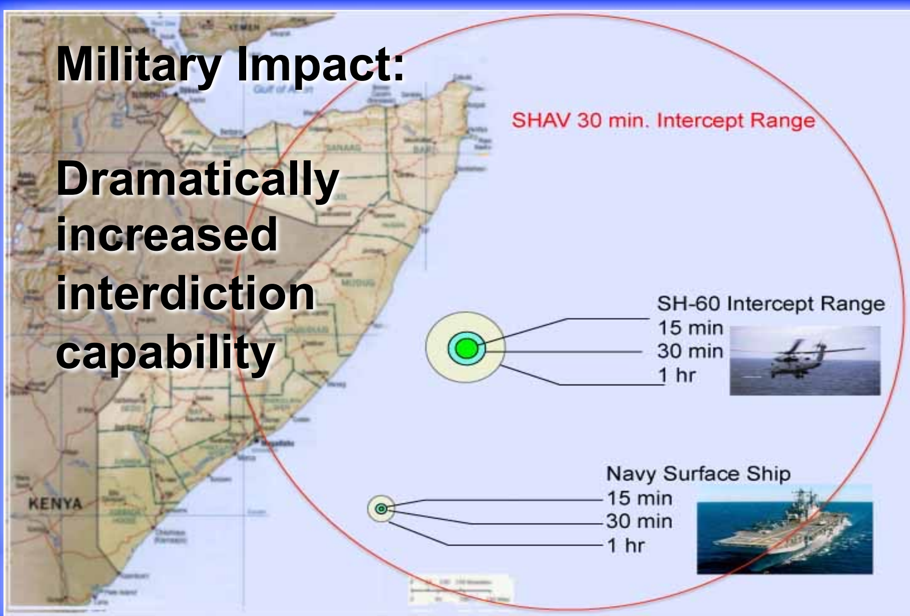


Description/Objectives/Methods

- New aircraft configuration & propulsion technology enables counterpiracy interdiction UAV
- New multi-mode powerplant is designed to function as a turboshaft in hover, turbojet ithrough the transonic and pressure-assisted ramjet through the high supersonic
- 13 years of convertible aircraft design expertise including the world's only hovering missile underpin the program via CFD, FEM & MDO techniques.
- Posted Videos show production, fielded Subsonic Hovering Missile Prototypes pioneered by the TRI team:
  http://www.youtube.com/watch?v=6448lIxJ3pE&feature=related
  http://www.youtube.com/watch?v=k2mFhrjfoFQ&feature=related
  http://www.youtube.com/watch?v=1CCbo_hWS-U&feature=related

Military Impact:

Dramatically increased interdiction capability



Budget & Schedule

Task	FY 12	FY13	FY14
1. SHAV Modeling			
2. SHAV Pwrplnt Design			
3. SHAVFabrication			
4. SHAV Tunnel Testing			
5. SHAV Flight Testing			

Budget: $5.5M/yr

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Ultra-High Sensitivity Acoustic Vector Sensor (AVS)

AVS is a mechanical analog to what bats do.

Description/Objectives/Methods

• A newly invented system improves the accuracy levels of the world's leading AVS systems by nearly an order of magnitude

• Because the leading AVS systems are foreign, other armed forces are taking advantage of this branch of technology to make highly advanced countersniper systems. Currently, the US has no edge in this area.

• This important improvement allows for nearly an order of mangitude in accuracy via increasing swept sensor areas, while maintaining nascent sensor form factor. Low Rn effects are mitigated by very high speed dynamic sweep patterns. The ultimate goal is to give vehicles the same situational awareness that bats possess either passively or actively.

Military Impact

Problem: Current forms of acoustic sensing technologies like ShotSpotter and Boomerang have limited accuracy levels, perform poorly when exposed to periodic signals (like propellers & turbines) and are easily confused by reflected waves.

• UAV sense and avoid systems, passive acoustic radar and highly accurate countersniper systems will enabled.

• Acoustic spatial sensing akin to that of bats is now enabled by this new technology

Budget & Schedule

Task	FY 10	FY11	FY12
1. UHSAVS Design	—		
2. UHSAVS Fabrication	—	—	
3. UHSAVS Aneochic Test		—	
4. UHSAVS Field Testing		—	—
5. Data Reduction			—

Budget: $300k/yr

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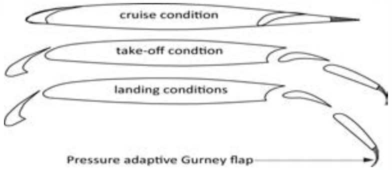
Concept of Technology

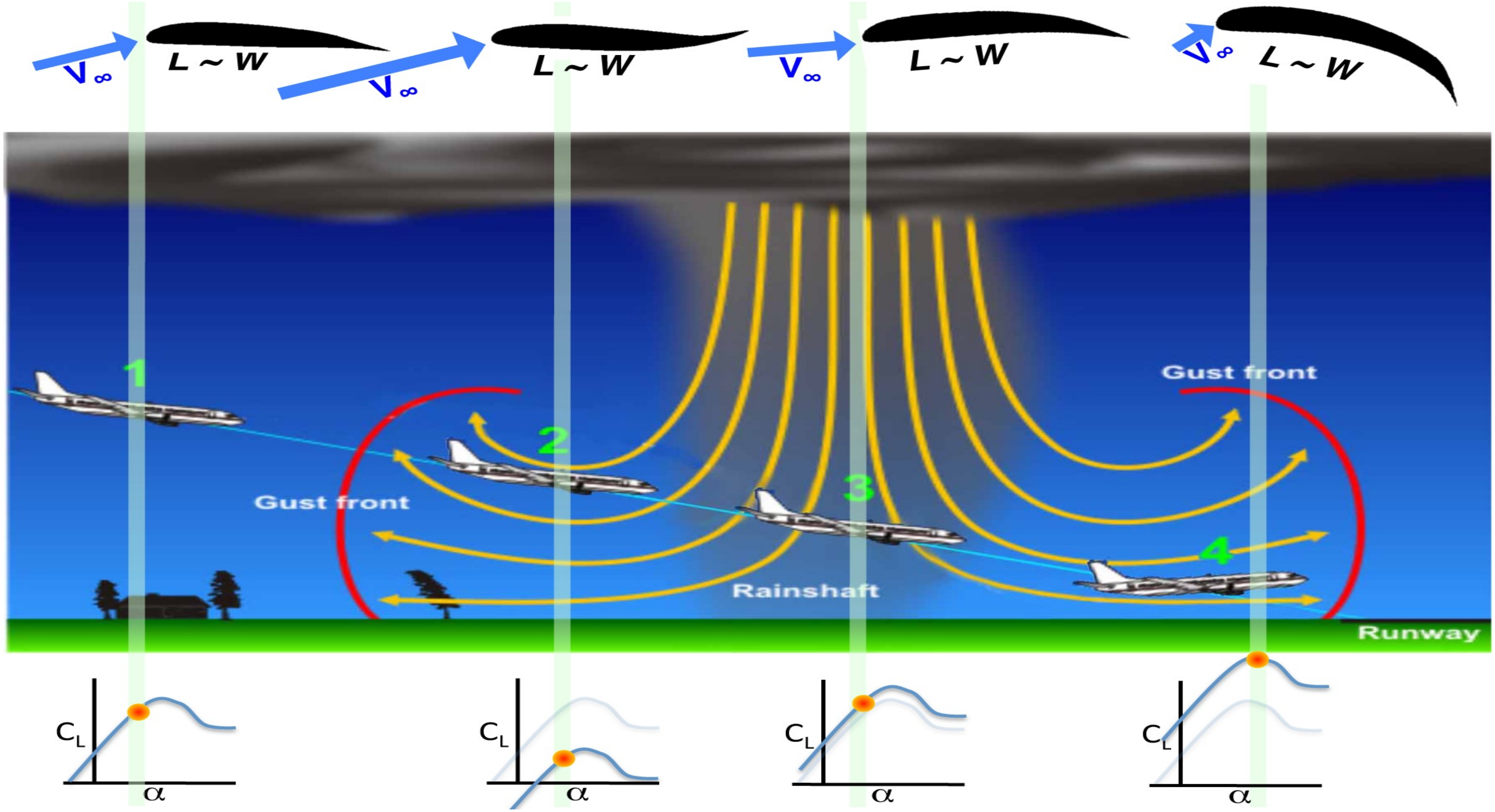
ConTech

Definition: A Concept of Technology (CONTECH) is a user-oriented document that "describes the characteristics of a particular technology from a user's perspective. A CONTECH also describes the interface with the whole machine, vehicle, system and/or system of systems and describes how it will enhance a particular mission characteristic on levels big and small."

Example Concept of Technology



Pressure Adaptive Honeycomb (PAH) Flap Systems



1. During steady flight, the PAH wing is trimmed at a given C_L.

2. Upon entering gust field, the PAH trailing edge deflects upwards, relieving lift, maintaining steady flight.

3. At the center of the downburst, the airfoil retrims itself to camber neutral.

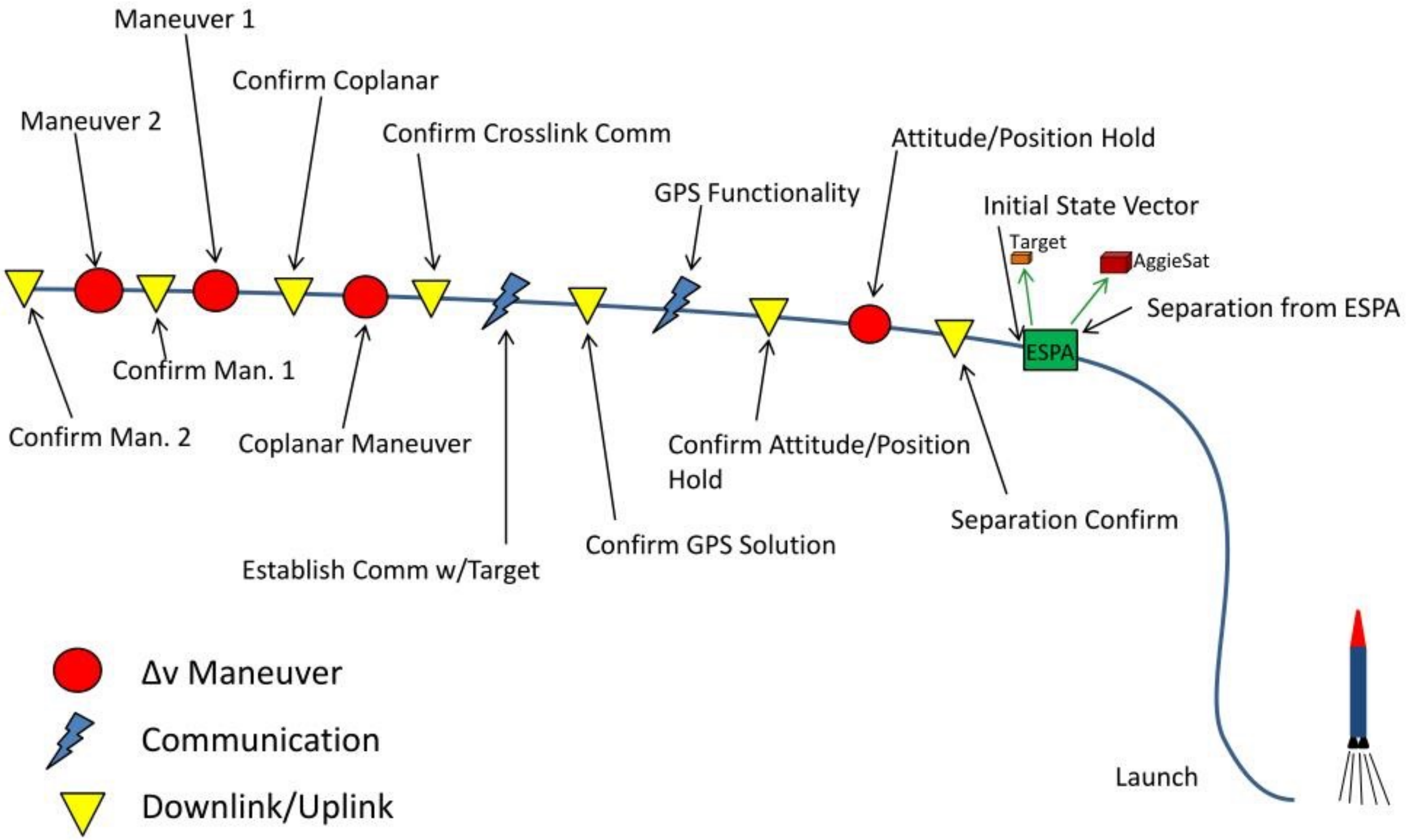
4. As the aircraft exits the gust field, the trailing edge deflects hard down, maximizing CL, maintaining steady flight.

Concept of Operations

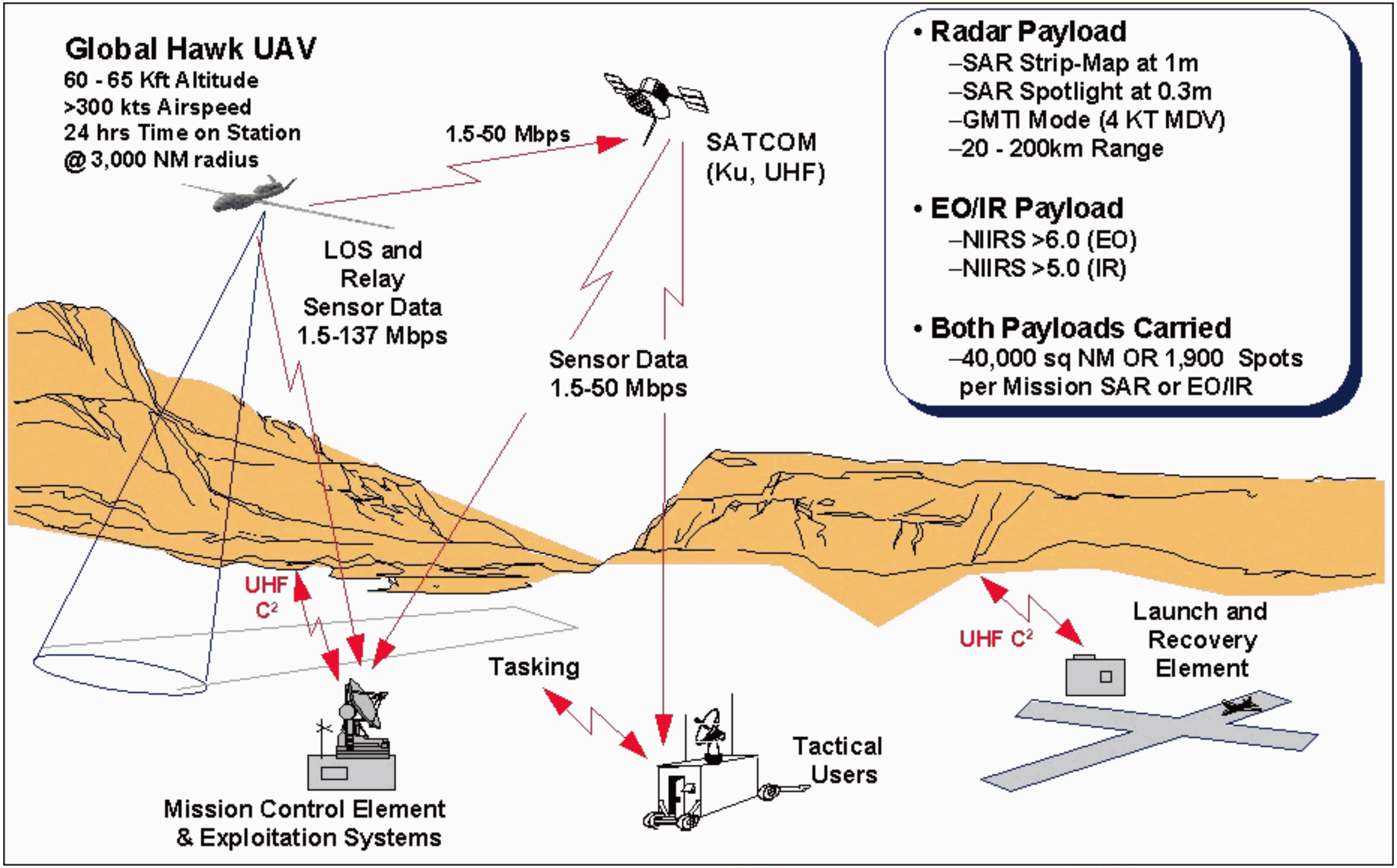
ConOps

Definition: A Concept of Operations (CONOPS) is a user-oriented document that "describes systems characteristics for a proposed system from a user's perspective. A CONOPS also describes the user organization, mission, and objectives from an integrated systems point of view and is used to communicate overall quantitative and qualitative system characteristics to stakeholders."

Very Basic Conops Example



Basic Conops Example



Basic Conops Example

BOEING

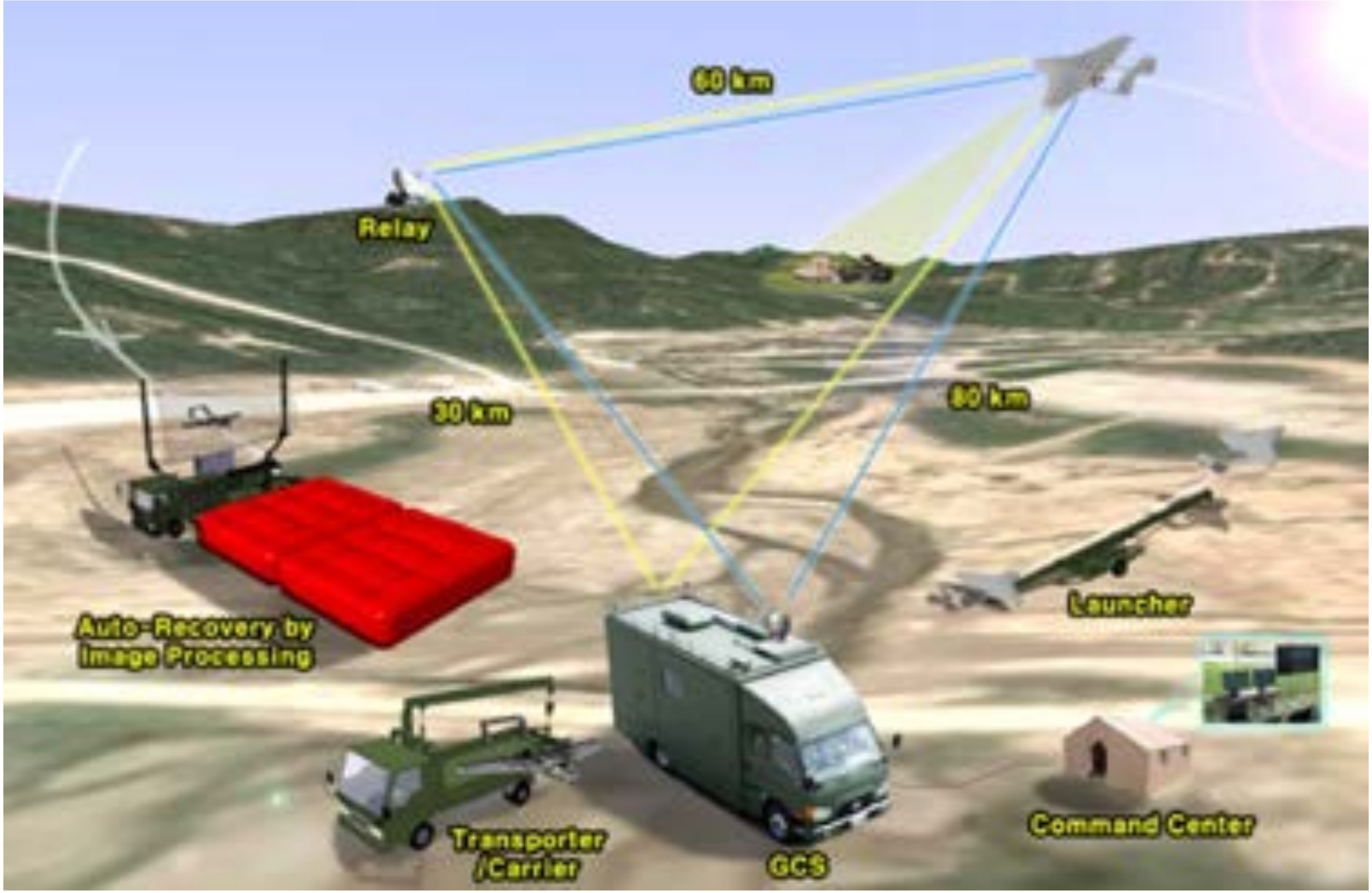
RAM 7 Conference 2014

Why SLED-STAMP?

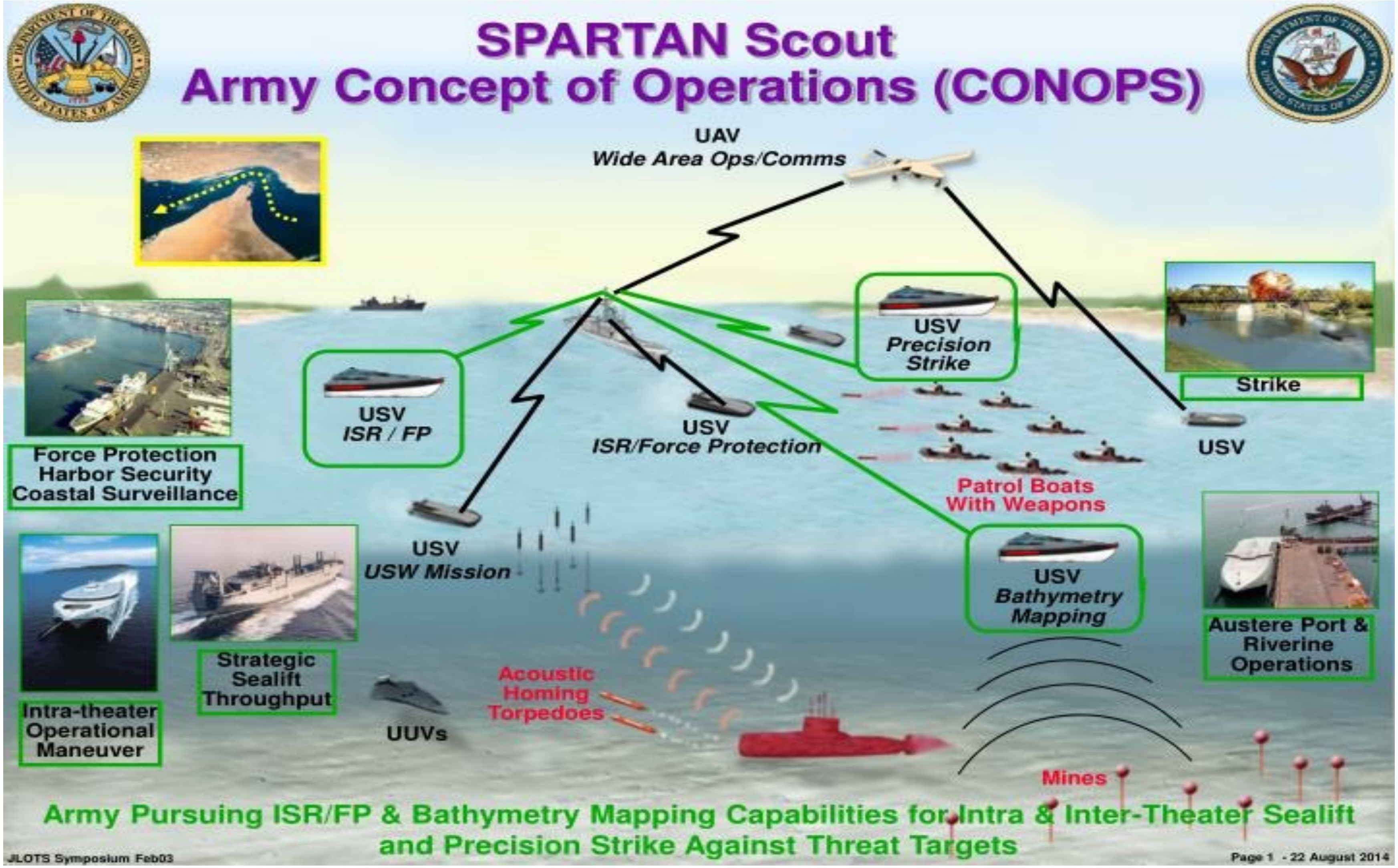
- Problem = Lack of Maintenance Situational Awareness
- Solution = Real Time “TOOL” = SLED-STAMP
  - Maintenance planning (P4T2) based on real-time, over-the-air fault reports
  - Improved accuracy and consistency in fault reporting
  - Provides Maintenance Production Control with useful planning data
    - Reduces troubleshooting time; potential increases in availability

Maintenance Concept of Operations (CONOPS) driven design

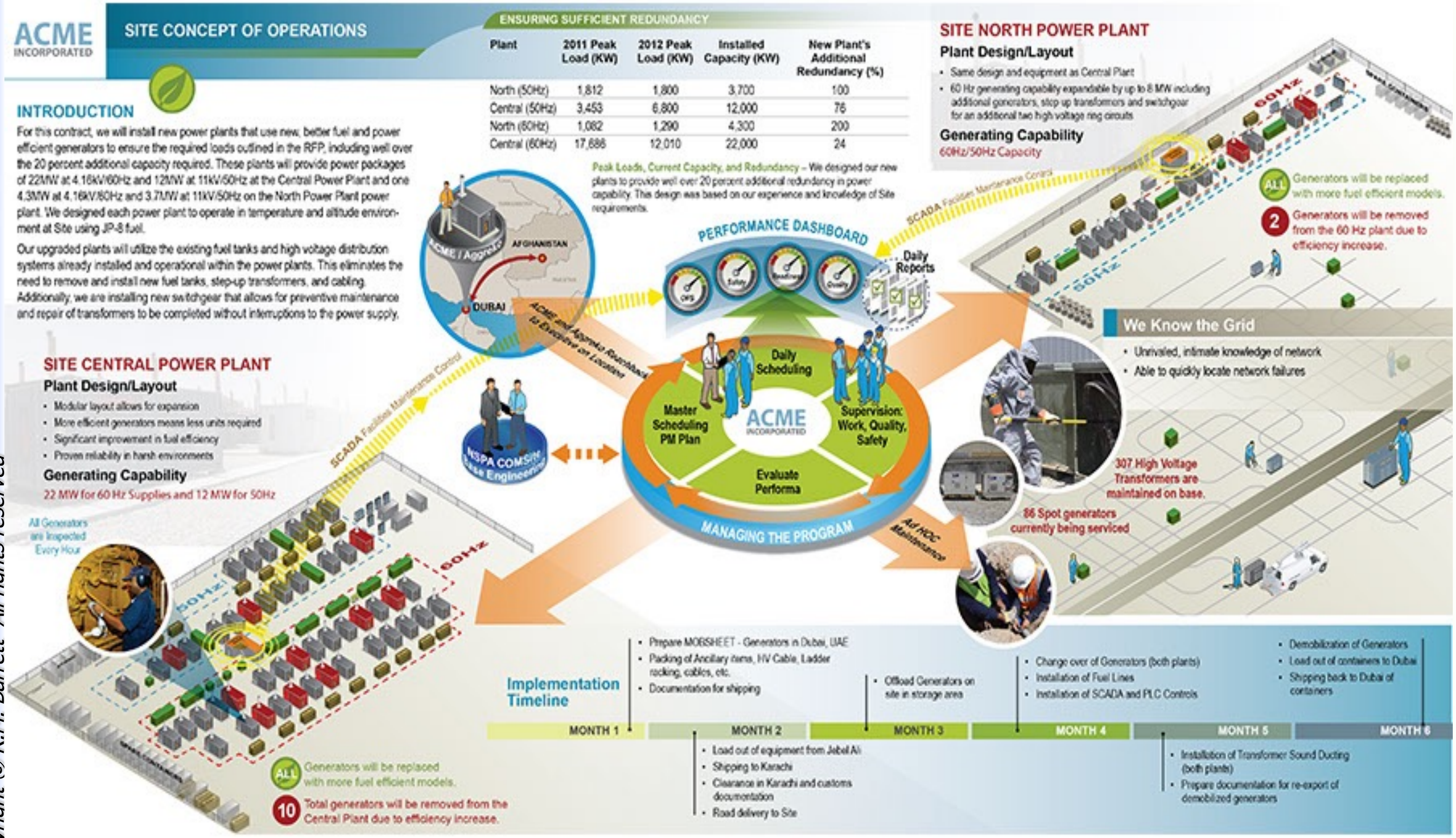
Conops Example Figure



Conops Example Figure

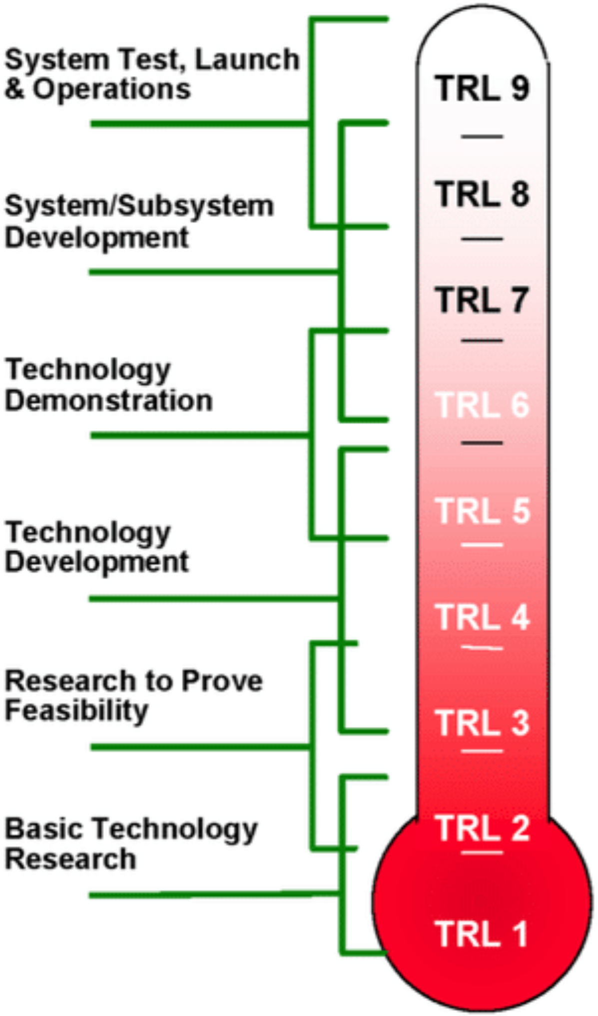


Conops Example Figure + Verbiage



Plant	2011 Peak Load (KW)	2012 Peak Load (KW)	Installed Capacity (KW)	New Plant's Additional Redundancy (%)
North (50Hz)	1,812	1,800	3,700	100
Central (50Hz)	3,453	6,800	12,000	76
North (60Hz)	1,082	1,290	4,300	200
Central (60Hz)	17,686	12,010	22,000	24

Technology Readiness Level (TRL)



- TRL 9: Actual system "flight proven" through successful mission operations
- TRL 8: Actual system completed and "flight qualified" through test and demonstration (Ground or Flight)
- TRL 7: System prototype demonstration in a space environment
- TRL 6: System/subsystem model or prototype demonstration in a relevant environment (Ground or Space)
- TRL 5: Component and/or breadboard validation in relevant environment
- TRL 4: Component and/or breadboard validation in laboratory environment
- TRL 3: Analytical and experimental critical function and/or characteristic proof-of-concept
- TRL 2: Technology concept and/or application formulated
- TRL 1: Basic principles observed and reported

Introduction to Systems Engineering

- "Some" concensus on precisely what SE is and what it does

- Some technologists profess to have the only "true" definitions, but there are no "absolute" terms. DoD, International Council on Systems Engineering (INCONSE), various professors all have their own slightly different language

- Basically: modern terminology and managerial jargon for what has been going on in the aerospace industry for more than a century

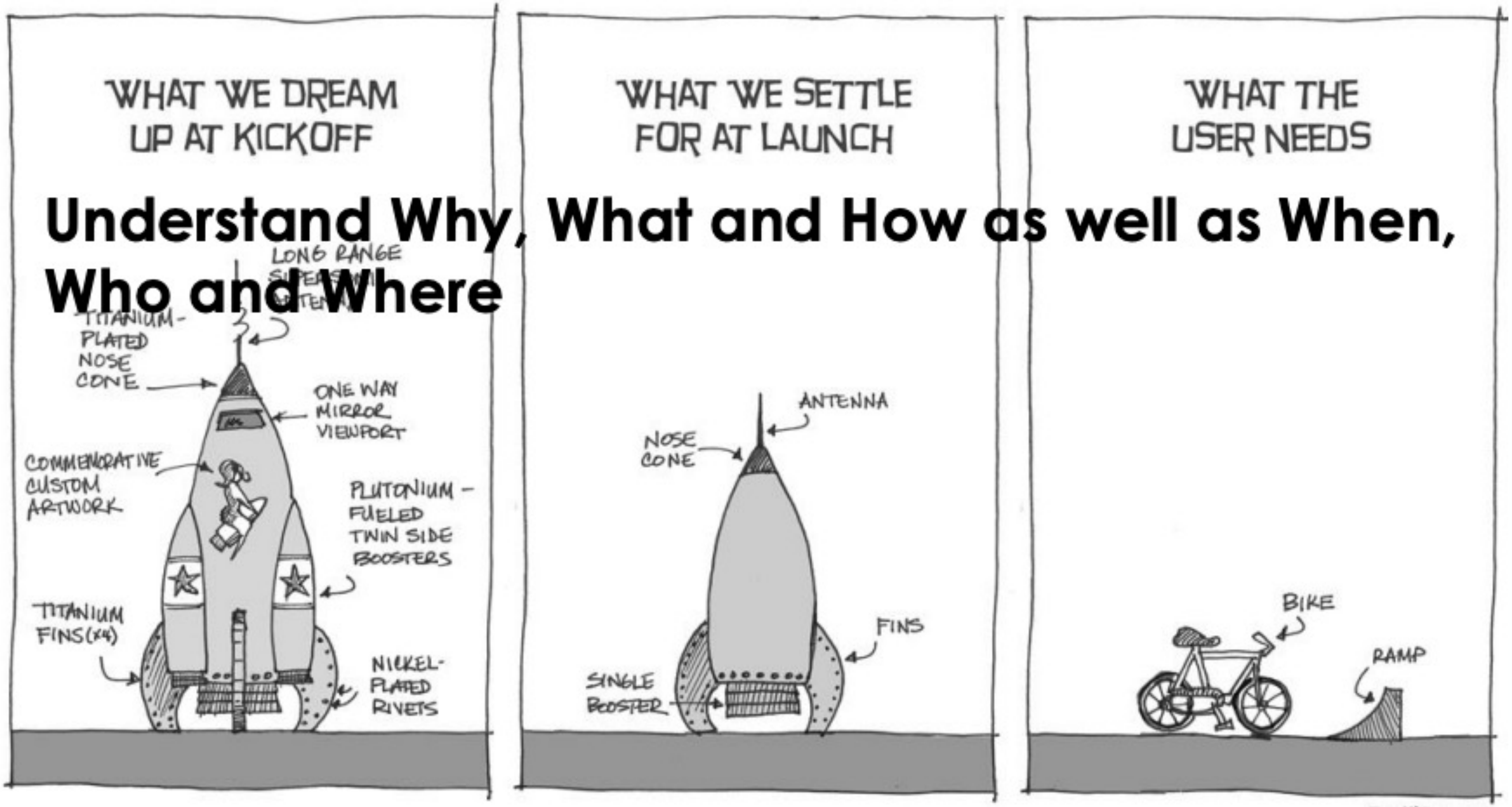
Introduction to Systems Engineering

Problem vs Solution:

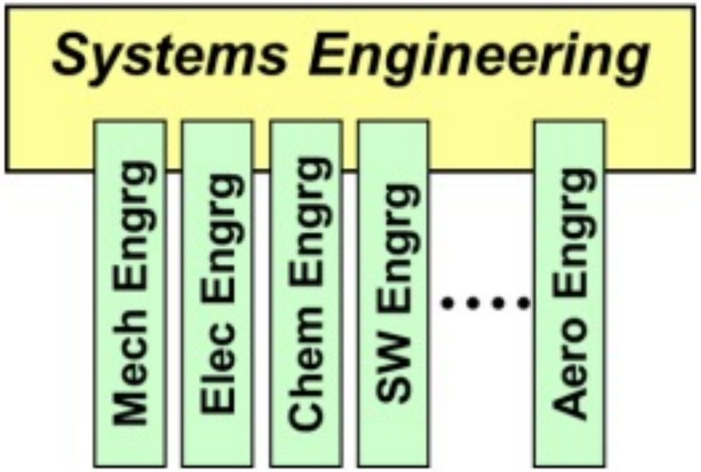
Introduction to Systems Engineering

Problem vs Solution:

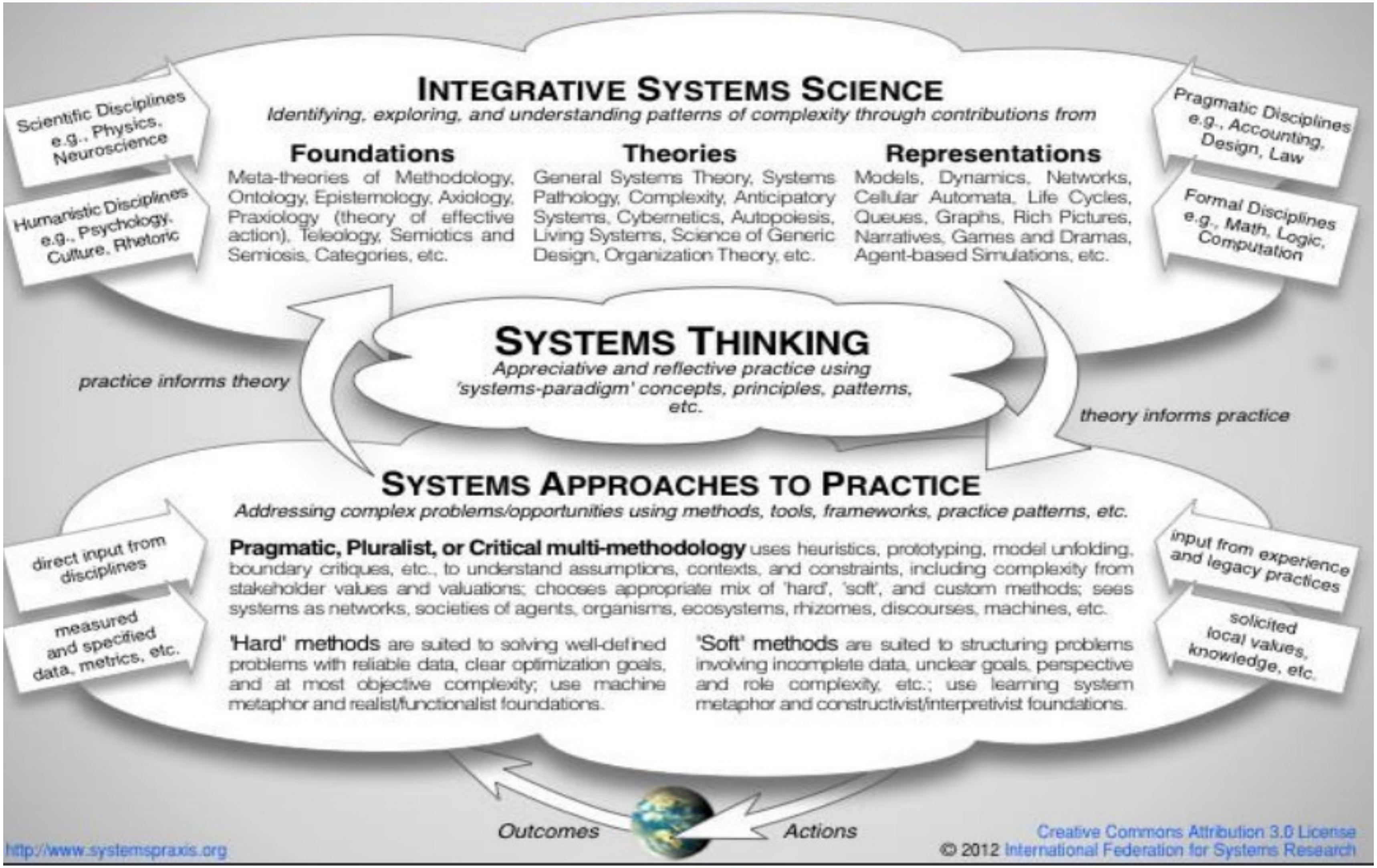
Understand Why, What and How as well as When, Who and Where



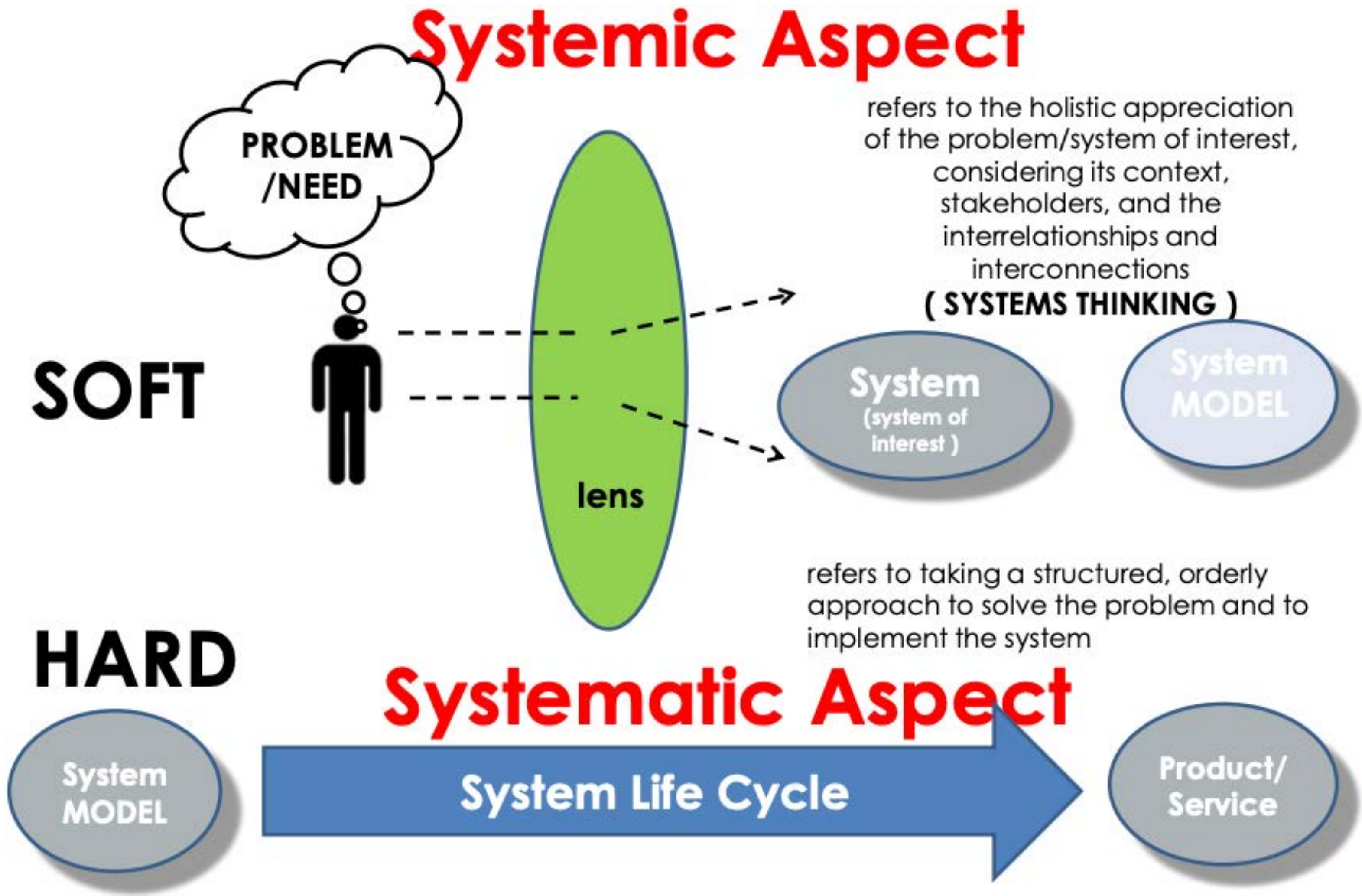
Introduction to Systems Engineering



Introduction to Systems Engineering



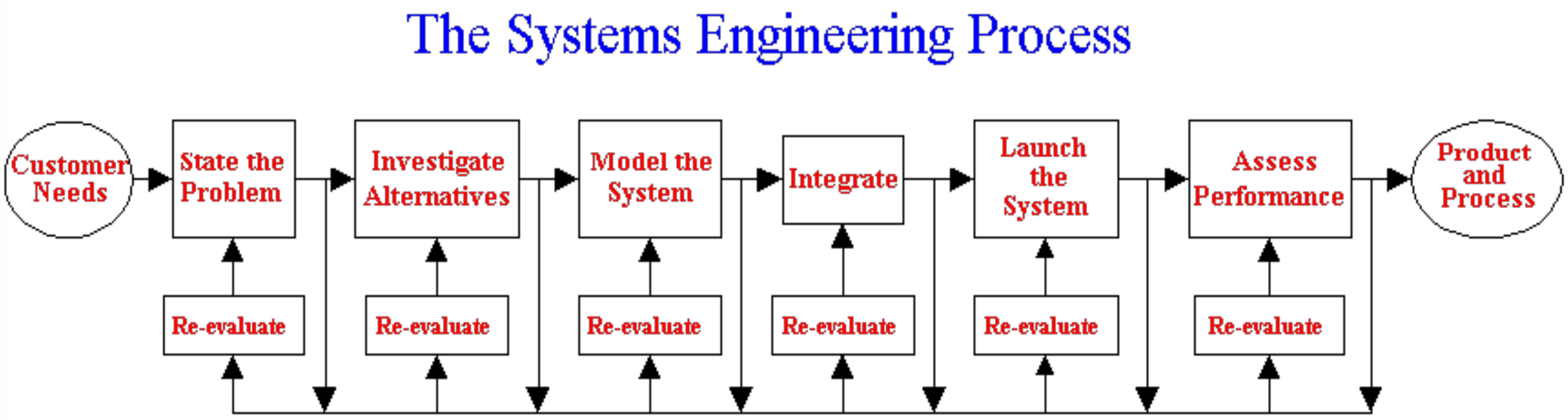
Introduction to Systems Engineering



Introduction to Systems Engineering

1937	British multidisciplinary team to analize the **air defence system**
1939-45	**Bell Labs** supports NIKE development (1st US operational anti-aircraft missile system) and Intercontinental Ballistic Missiles (ICBM) Program.
1951-80	**SAGE** (Semi-automatic Ground Enviroment) Air Defense System defined and managed by MIT/Jay Forrester
1956	Invention of **systems analysis** by RAND corp.
1960-70	**Apollo Program** First SE standards (e.g. MIL-STD 499, NASA procedures)
1962	Publication of Arthur D. Hall – **A Methodology for Systems Engineering**
1989	EIA recognizes **SE as important part of system development**
1990	**NCOSE** is founded
1990-2000	Release of **SE standards IEEE 1220, EIA 632**
1994	NCOSE renamed to **INCOSE**
2002	Release of **ISO/IEC 15288**
2008	**App. 6500** INCOSE members worldwide
2009-2012	Systems Engineering Body of Knowledge (**SEBoK**)
2019	**17000+** INCOSE members worldwide (70+ Chapters 35+ Countries)
2023	**INCOSE Systems Engineering Handbook version 5**

Introduction to Systems Engineering



Introduction to Systems Engineering

System Requirements

1. Mandatory requirements insure that the system satisfies the customer's operational need. Mandatory requirements (1) specify the necessary and sufficient conditions that a minimal system must have in order to be acceptable (2) must be passed or failed, there is no middle ground, and (3) must not be susceptible to trade-offs between requirements. Typical mandatory requirements might be of the following form: The system shall not violate federal, state or local laws. Mandatory requirements state the minimal requirements necessary to satisfy the customer's need.

2. Tradeable Requirements (Objectives) are evaluated to determine the preferred designs. Tradeoff requirements (1) should state conditions that would make the customer happier (2) should use scoring functions to evaluate the criteria, and (3) should be evaluated with multicriterion decision aiding techniques because there will be trade-offs between these requirements.

Sometimes there is a relationship between mandatory and tradeoff requirements, e.g. a mandatory requirement might be a lower threshold value for a tradeoff requirement. The words optimize, maximize, minimize and simultaneous should not be used in stating

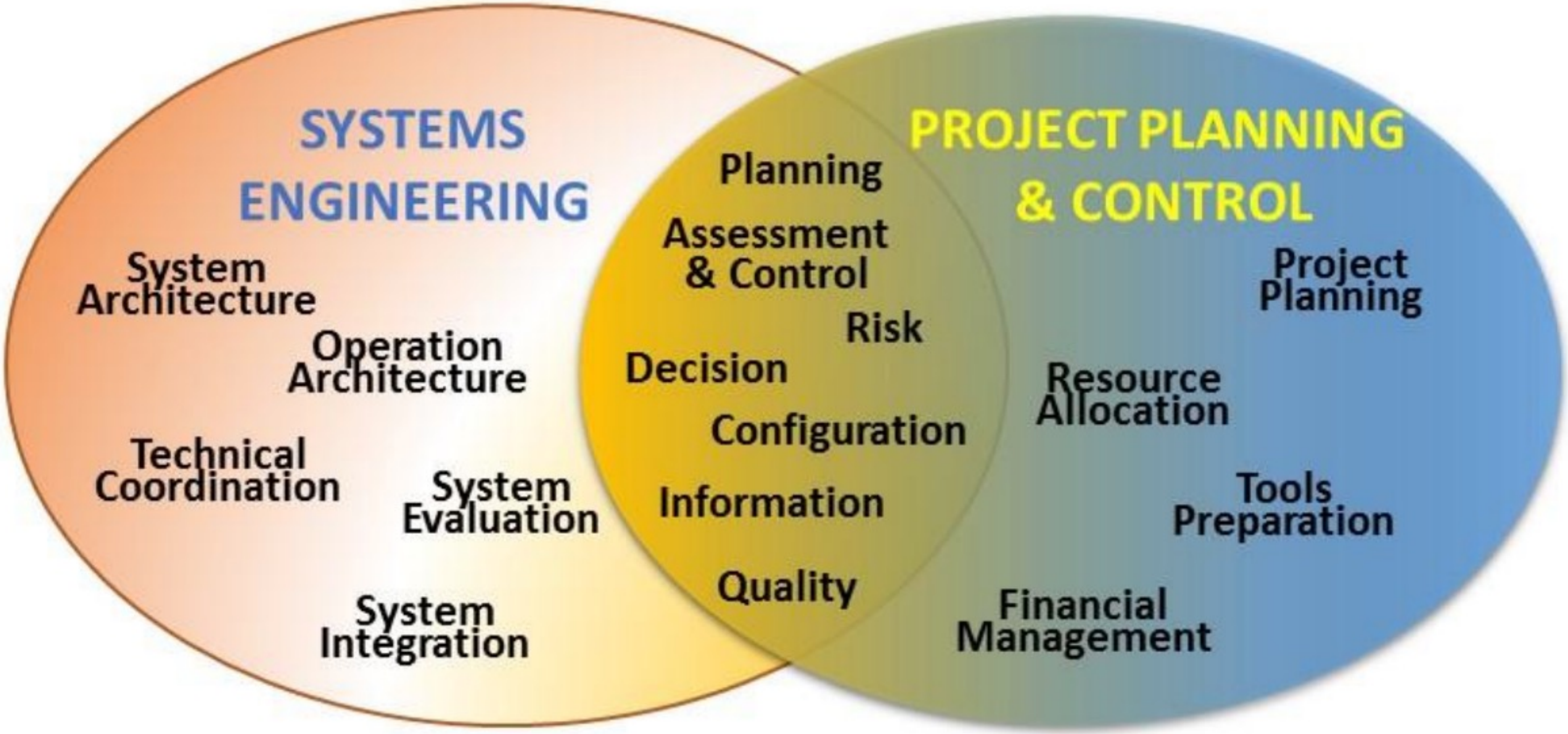
Quality function deployment (QFD) is useful in identifying system requirements

Verify and validate requirements
Each requirement should be verified by logical argument, inspection, modeling, simulation, analysis, test or demonstration.
Validating requirements means ensuring that

1) the recommended solution satisfies the actual needs of the customer
2) the description of the requirements is consist and complete
3) a system model can satisfy the requirements
4) a real-world solution can be tested to prove that it satisfies the requirements.

Requirements are often validated by reference to an existing system that meets most of the requirements.

Introduction to Systems Engineering

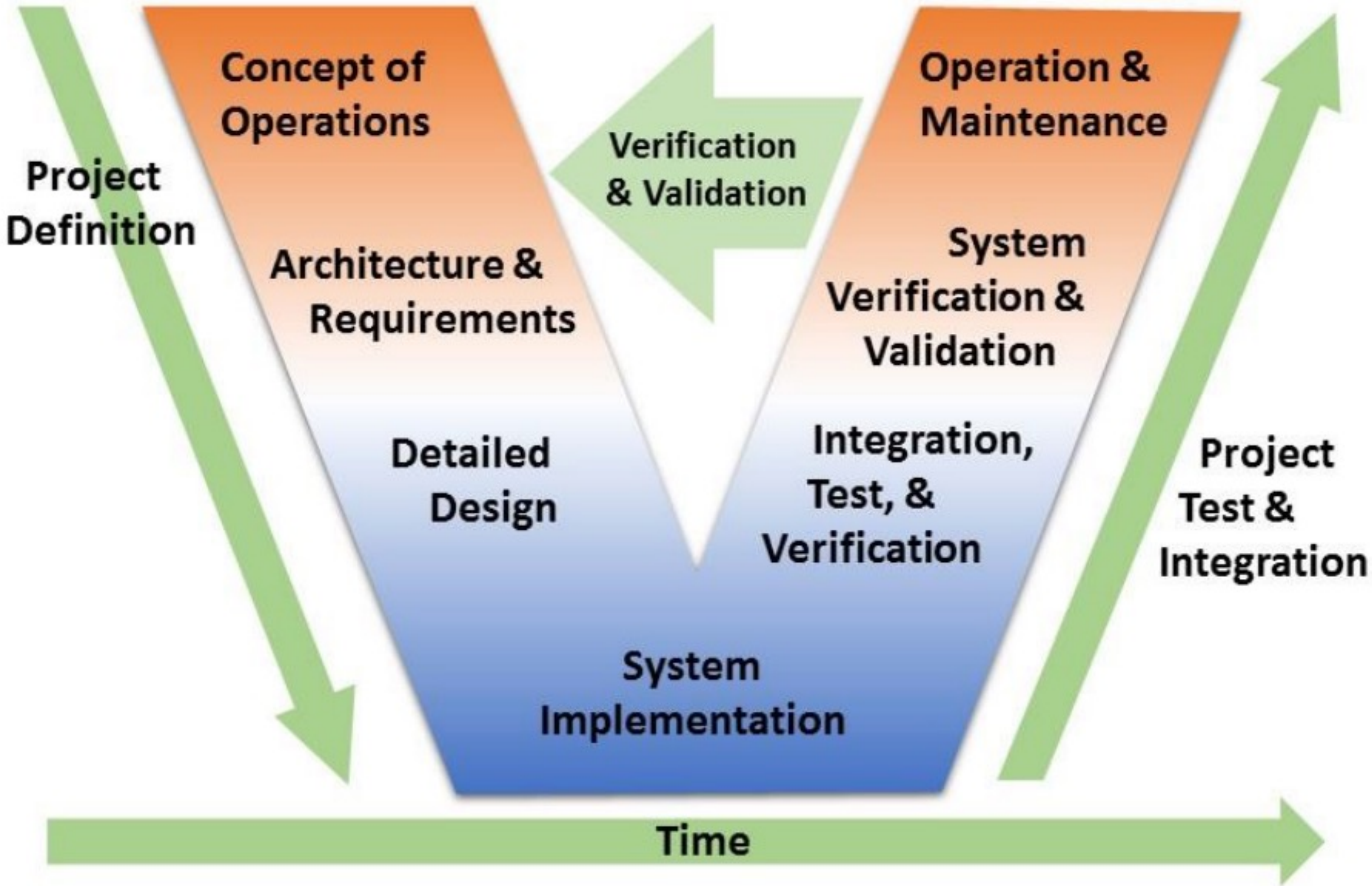


Introduction to Systems Engineering

ISO 15288

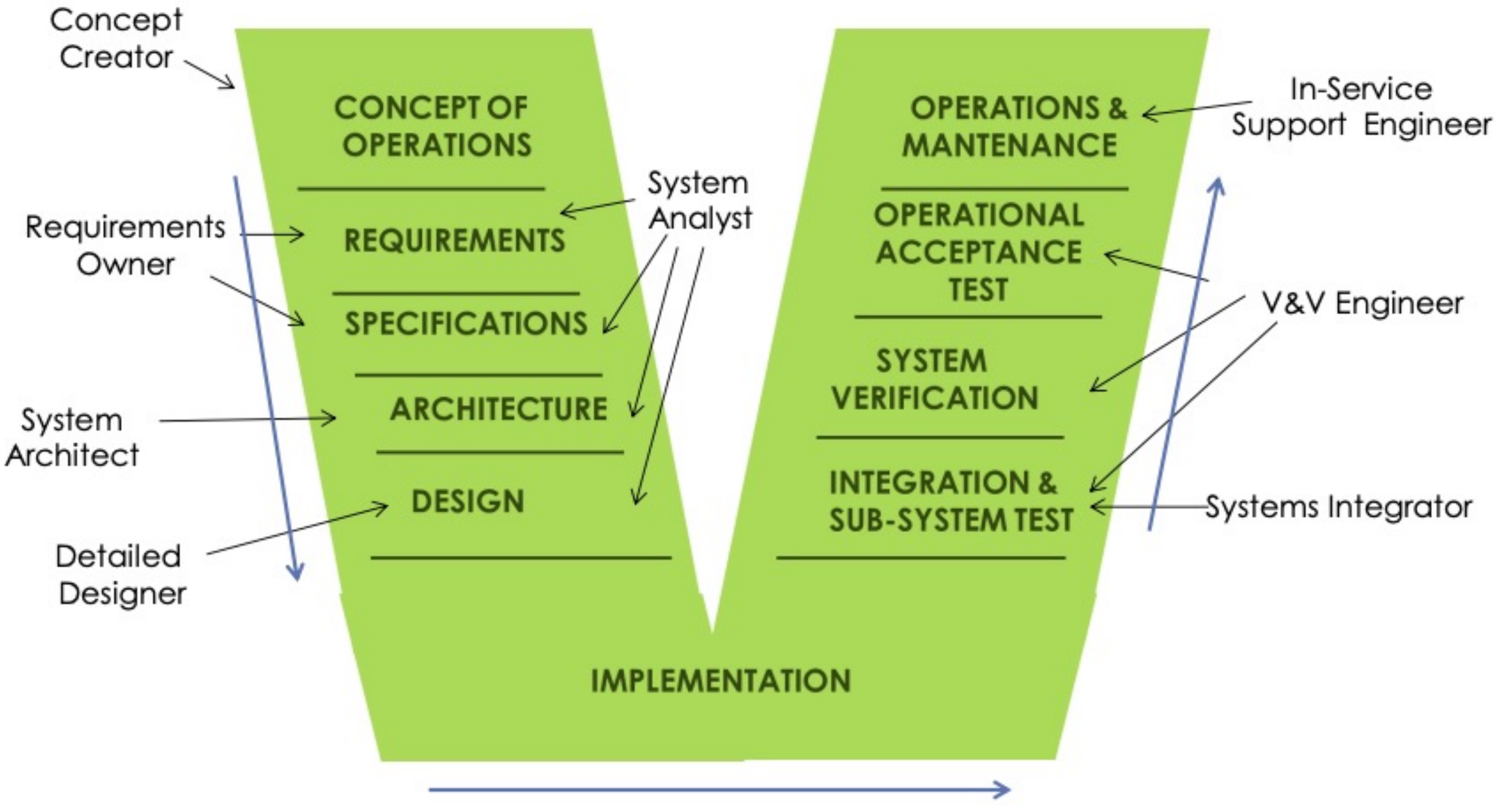
Agreement Processes	Organizational Project-Enabling Processes	Technical Management Processes	Technical Processes
Acquisition Process	Life Cycle Model Management Process	Project Planning Process	Business or Mission Analysis Process
Supply Process	Infrastructure Management Process	Process Assessment and Control Process	Stakeholder Needs & Requirements Definition Process
	Portfolio Management Process	Decision Management Process	System Requirements Definition Process
	Human resource Management Process	Risk Management Process	Architecture Definition Process
	Quality Management Process	Configuration Management Process	Design Definition Process
	Knowledge Management Process	Information Management Process	System Analysis Process
		Measurement Process	Implementation Process
		Quality Assurance Processy	Integration Process
			Verification Process
			Transition Process
			Validation Process
			Operation Process
			Maintenance Process
			Disposal Process

Introduction to Systems Engineering



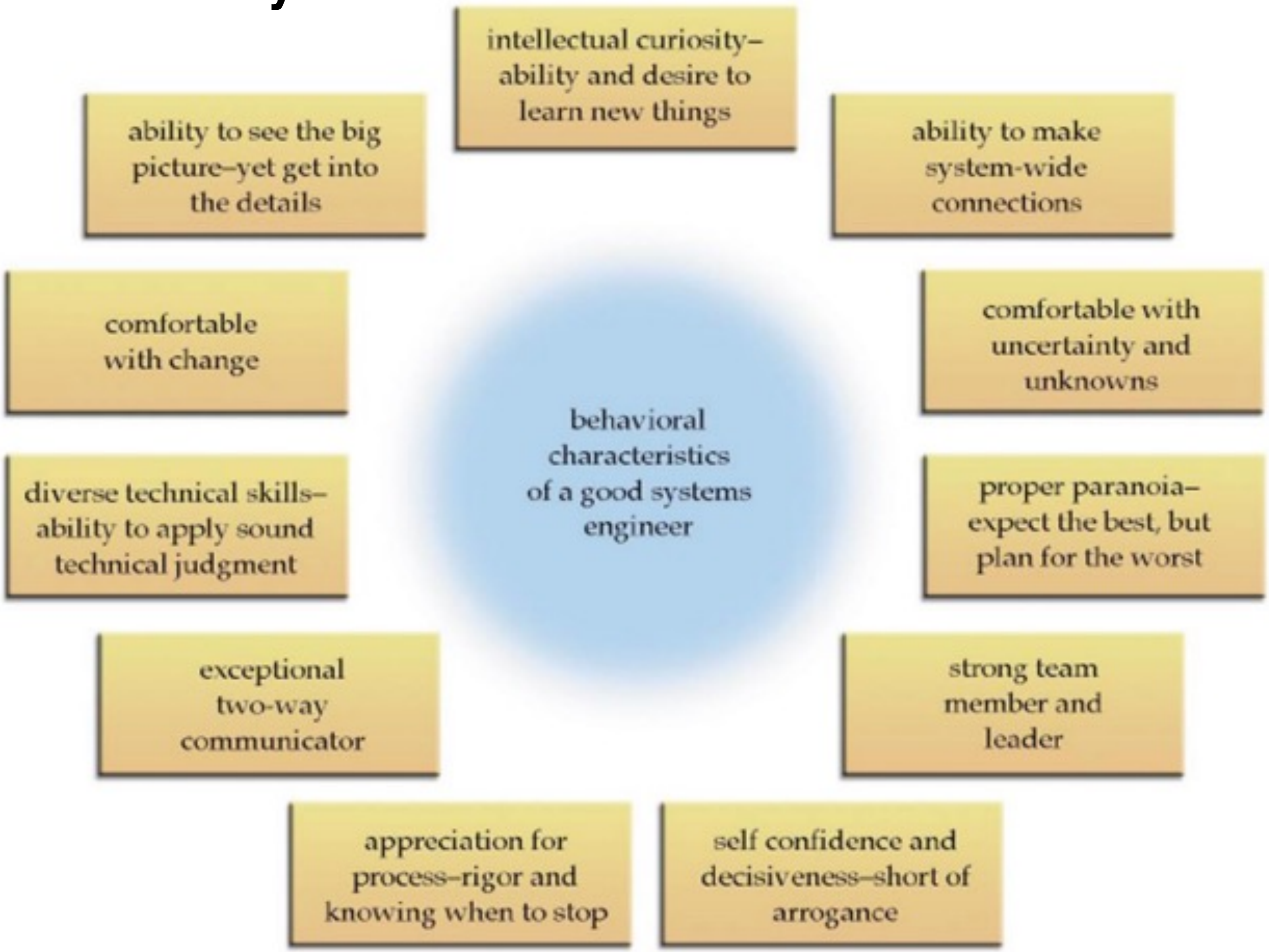
Introduction to Systems Engineering

A role is the part that is played within a specific work process and within the company. Systems engineers will typically hold many positions, each with a different combination of roles.



Introduction to Systems Engineering

Desired SE Personality Traits



Thursday 12 September 2023

Today's Schedule:

- Call Roll
- Service/Outreach Sign-Ups:
  - Mon. 10/23 Eisenhower Middle School, Abilene
  - Mon. 10/30 Wamego Middle School
  - Sat. 12/2 Flint Hills Discovery Center, Manhattan
  - Sat. 12/9 Flint Hills Discovery Center, Manhattan
  - ? Farley Elementary visit to KU Campus
- Mid-Semester Jeopardy/Quiz Questionnaire
- Competitions
- Small Report 5

AEROSPACE JEOPARDY!

Fall 2023 Outreach Activities Driver/Rider signups

	Mon. 10/23	Mon. 10/30	Sat. 12/2	Sat. 12/9
Ativie,Joseph			x	
Bailey,Lucy M				
Barland,Jack A	x		x	
Bonham,Maggie E		x		
Braaten,Niels C		x		
Caulfield,Camden Lee				
Coppens,Ryan				
Dargahi,Alex			x	
Denault,Carson Robert		x		
Deng,Keyu			x	
Dillon,Peter				
Dodge,Andrew				
Dunlay,Joshua P	x			
Dutta,Sap				
Foster,Dean C	x		x	x
Gillies,Gunnar			x	x
Goudschaal-Frazier,Gracyn Jane				
Guzman,Jonathan Alan		x		
Harder,Samuel A			x	x
Heide,Rhett Gile	x		x	
Horst,Evelyn			x	
Hunt,Wesley Afra	x			
Junnare,Nupoor	x	x		
Keathley,Liliana Gabriel				
King,Kathryn M				
Kuligowski,Payton M			x	x
Larsen,Isaac		x		x
Linthavong,Cherry			x	
Lofland,Chris C	x	x		
Marshall,Jeb O	x		x	x
Mays,Benjamin S		x		
Mcmichael,Barrett			x	x
Mcnulty,Jack B		x		
Mistretta,Anthony J		x		
Olson,Kadin Lee	x		x	
Platt,Charlie M		x		
Poznanski,Joshua	x	x	x	x
Reida,Reanne N			x	x
Reidy,Macoy M		x	x	
Relan,Jennifer	x	x	x	x
Richardson,Jake	x		x	x
Russell,Lucas S	x		x	x
Schneider,Cade W	x		x	x
Shah,Dhairya	x	x		
Sullivan,Tim Michael				
Sutton,Joshua T				x
Svoboda,Benjamin C		x		
Thorson,Johnathan A		x		
To,Hoang Minh			x	
Torok,Jackson P				x
Torres Leon,Hector	x		x	
Waggoner,Alex				x
Wall,James Edgar			x	
Wegiel,Jeremy L				

UPCOMING AEROSPACE JEOPARDY TOPICS

Game 3	Commercial Transports	General Aviation	Fighters	Aircraft Designers	Aerodynamics	Stability & Control
Game 4	Amphibians	Homebuilts	Interceptors	Politicians	Performance	Materials & Processes
Game 5	Bombers	Autogyros	Lighter than Air	Military Leaders	Propulsion	Structures
Game 6	Before WWI	Naval Aviation	Transport Helicopters	Aerospace Professors	Strength of Materials	Fluid Mechanics
Game 7	Gliders	X-Planes	Launch Vehicles	Astronauts	Weight Sizing	Conversions
Game 8	Cold War	Tactical Missiles	Commercial Transports	First Flights	Stability and Control	Piston Engines
Game 9	Russian Aerospace	European Aerospace	Canadian Aerospace	Doctrines & Agreements	Rocket Engines	Jet Engines
Game 10	Experimental Airplanes	Experimental Rotorcraft	Attack Airplanes	Corporate Leaders	Wing Sizing	Configurations
Game 11	Business Transports	Prehistoric Aerospace Devices & Lore	VTOL Aircraft	KU Professors	Stability and Control	Exoatmospherics
Game 12	NASA Trivia	Surface-to-Air Missiles	Unusual Weapons	Aerospace Laws	The Atmosphere	Materials & Processes
Game 13	Military Transports	Pioneer Years	Low Observables Aircraft	Combat Pilots	Supersonic Aerodynamics	Aircraft Configurations
Game 14	Aerospace Economics	Strategic Missiles	Hard-Launched Munitions	Aerospace Museums	Guidance, Navigation & Control	Aerospace Safety Practices
Game 15	Urban Air Mobility	Flying Toys and Sports	Air Crashes and Fatalities	KU & KUAE History	Design Practices	Circuits and Instrumentation
Game 16	Record Setters	Failed Designs	Aerospace Scandals & Cover-Ups	Dirty Politics	Design Practices	Finite Element Methods

AE 521 Jeopardy/Quiz Questionnaire

(Circle your choices)

Do you want Dr. B. to continue with the buzzer quiz/Jeopardy type edutainment games in the last hour of class periods?

Yes No

Do you want Dr. B. to revert to straight up "normal" Powerpoint buzzer quiz format or keep the Jeopardy format?

"Normal" Buzzer Quiz format Jeopardy format

Do you feel that you have learned or are learning from the buzzer quiz/Jeopardy edutainment games?

Yes No

Suggestions for improvement:

Why do we compete?

i.) Proper training

-Most things you will do in your working life will be competitive

Why do we compete?

i.) Proper training

- -Most things you will do in your working life will be competitive

ii.) Enable you to work as a member of a competitive team

- -Think strategically
- -Hone time and personnel management skills
- -Make a better product/outcome than the competition

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iii.) Demonstrate your skills to others outside of KU
- -Helps you, personally
- -Helps maintain the reputation of KUAE grads w/in industry
- -Enhances your employability & that of future Jayhawks
- -Helps maintain national rankings of KUAE Department

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iv.) Solidify friendships – you'll need them

v.) Have a better life

Spring Competitions

AE 522/722 Teams

- Seniorocracies, NOT Democracies

- Good to recruit both <Seniors & non-AE's
  - Juniors are generally best – good CAD
  - Underclassmen used for STAMPED data
  - Photoshop, Paint, Illustrator skills useful
  - Architecture & Design students great renderings
  - Art students awesome for real artwork

Spring Competitions

AE 522/722 Teams

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  - Juniors are generally best - good CAD
  - Underclassmen used for STAMPED data
  - Photoshop, Paint, Illustrator skills useful
  - Architecture & Design students great renderings
  - Art students awesome for real artwork

- Sooner teams established, sooner recruiting begins

- Good team structure:
  1 Über-organizer
  + 2-4 Motivated AE Seniors
  + 1-2 AE Juniors with great CAD chops
  + 1-2 AE Underclassmen
  + 1-3 Arch./Design/Art students

Spring Classes & Activities

AE 522

- AIAA UGrad. competitions
- VFS UGrad. Competition
- (Special Design Spec. for non-competitors)

AE 592

- AIAA DBF – get 1-3 hrs tech. elective credit. Will NOT count as 2nd Design course

AE 722

- VFS Grad. Team VTOL
- AIAA Grad. Team Aircraft
- AIAA Grad. Team Missile

Spring Competitions – Structure & Judging

AE 522

- AIAA UGrad. Team Heavy Lift
  - We have great contacts among alumni to help
  - Judges stacked against us – many with conflicts of interest
  - Largest field – 54 competitors last year
  - Not after best concept, mostly diversity well-known of non-KU institutions
  - Last big win was 2014
  - Path to win award is to join up with foreign university, let them glue their name on the report, we do the work.
  - Winning concepts have been mixed, but mostly conservative

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- AIAA UGrad. Individual Strato. Payload
  - Most other schools don't prepare individuals well for individual, so we're competitive
  - Highest probability of winning a prize (we've done well in the past)
  - NEWT is somebody's pet project – must do deep research
  - More work than team, but no team "baggage" to haul around

Spring Competitions – Structure & Judging

AE 522

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  - NEWT is somebody's pet project – must do deep research
  - More work than team, but no team "baggage" to haul around

- VFS UGrad. Disaster Relief UAS
  - Competition tilted towards "big rotorcraft" schools
  - Good only for people who are truly interested in VTOL
  - Possible to crack with wind tunnel, CFD and/or flight tests
  - Winning concepts have been mixed – some conservative, some aggressive

Spring Competitions – Structure & Judging

AE 522

- AIAA UGrad. Team Heavy Lift
  - We have great contacts among alumni to help
  - Judges stacked against us – many with conflicts of interest
  - Largest field – 54 competitors last year
  - Not after best concept, mostly diversity well-known of non-KU institutions
  - Last big win was 2014
  - Path to win award is to join up with foreign university, let them ... e on the report, we do the work.
  - Winning concepts have been mixed, but mostl...
- AIAA UGrad. Individual Strat...
  - Most other schools d... ...ividuals well for individual, so we're competitive
  - Highest pr... ...ing a prize (we've done well in the past)
  - N... ...ay's pet project – must do deep research
  - ... work than team, but no team "baggage" to haul around

Good to enlist Design, Architecture & Graphics Arts students

- VFS UGrad. Disaster Relief UAS
  - Competition tilted towards "big rotorcraft" schools
  - Good only for people who are truly interested in VTOL
  - Possible to crack with wind tunnel, CFD and/or flight tests
  - Winning concepts have been mixed – some conservative, some aggressive

Spring Competitions – Structure & Judging

AE 592

- AIAA DBF
  - Great for team building
  - Weather a big factor
  - No straightforward way to win
  - Wonderful, but maddening crap shoot
  - Winners "game the rules" the best
  - Hardware at airport = obstacle, but manageable
  - Often devolves to $ contest
  - National teams bring $100+k worth of aircraft
  - Trip expensive & exhausting, but fun
  - Massive learning experience at all levels
  - Hiring managers love to hear about DBFish activities

Spring Competitions – Structure & Judging AE 722

- VFS Grad. Disaster Relief UAS
  - Really hard given top rotorcraft schools always win
  - We have "ace in the hole" in terms of experience & flight test data
  - Top rotorcraft schools teach 9 – 12 helicopter classes…
  - We teach 1 helicopter class… On a good year

Spring Competitions – Structure & Judging AE 722

- VFS Grad. Disaster Relief UAS
  - Really hard given top rotorcraft schools always win
  - We have "ace in the hole" in terms of experience & flight test data
  - Top rotorcraft schools teach 9 – 12 helicopter classes…
  - We teach 1 helicopter class… On a good year

- AIAA Grad. Team Aircraft Electric Sailplane
  - Judging straightforward, little funny business detected
  - We have strategic advantage via Prof. Depcik
  - This year challenging, but well within reach
  - Good chance of success

Spring Competitions – Structure & Judging AE 722

- VFS Grad. Disaster Relief UAS
  - Really hard given top rotorcraft schools always win
  - We have "ace in the hole" in terms of experience & flight test data
  - Top rotorcraft schools teach 9 – 12 helicopter classes…
  - We teach 1 helicopter class… On a good year

- AIAA Grad. Team Aircraft Electric Sailplane
  - Judging straightforward, little funny business detected
  - We have strategic advantage via Prof. Depcik
  - This year challenging, but well within reach
  - Good chance of success

- AIAA Grad. Team Rapid Reaction Satellite Launcher
  - Extremely tough, but fair. Graduates highly sought.
  - Top prize = well executed design on only what they want
  - Georgia Tech fields giant team & 3+ faculty + giant codes
  - 2nd & 3rd place = best technical solution, but not what they want

Spring Competitions – Structure & Judging

AE 722

- VFS Grad. Disaster Relief UAS
  - Really hard given top rotorcraft schools always win
  - We have "ace in the hole" in terms of experience & flight test data
  - Top rotorcraft schools teach 9 – 12 helicopt… …
  - We teach 1 helicopter class… On… …a.

Good to get Design & Graphics Arts students

- AIAA Grad. Team … Electric Sailplane
  - Judging …ghtforward, little funny business detected
  - We have strategic advantage via Prof. Depcik
  - This year challenging, but well within reach
  - Good chance of success

- AIAA Grad. Team Rapid Reaction Satellite Launcher
  - Extremely tough, but fair. Graduates hi… …gh…
  - Top prize = well executed des… …y what they want
  - Georgia Tech fiel… …m & 3+ faculty + giant codes
  - 2^{nd} & 3^{rd} … best technical solution, but not what they want

Recruit some of Dr. Wang's CFD Students

Think about which one(s) you want to do…

Student	AIAA UGTeam Heavy Lift	AIAA UG Indiv. Strato Payload	AIAA GTeam Electric Sailplane	AIAA Missile	VFS Disaster Relief UAS	Other	Graduation
Ativie,Joseph							
Bailey,Lucy M							
Barland,Jack A							
Bonham,Maggie E							
Braaten,Niels C							
Caulfield,Camden Lee							
Coppens,Ryan							
Dargahi,Alex							
Denault,Carson Robert							
Deng,Keyu							
Dillon,Peter							
Dodge,Andrew							
Dunlay,Joshua P							
Dutta,Sap							
Foster,Dean C							
Gillies,Gunnar							
Goudschaal-Frazier,Gracyn Jane							
Guzman,Jonathan Alan							
Harder,Samuel A							
Heide,Rhett Gile							
Horst,Evelyn							
Hunt,Wesley Afra							
Junnare,Nupoor							
Keathley,Liliana Gabriel							
King,Kathryn M							
Kuligowski,Payton M							
Larsen,Isaac							

Think about which one(s) you want to do...

Student	AIAA UGTeam Heavy Lift	AIAA UG Indiv. Strato Payload	AIAA GTeam Electric Sailplane	AIAA Missile	VFS Disaster Relief UAS	Other	Graduation
Linthavong,Cherry							
Lofland,Chris C							
Marshall,Jeb O							
Mays,Benjamin S							
Mcmichael,Barrett							
Mcnulty,Jack B							
Mistretta,Anthony J							
Olson,Kadin Lee							
Platt,Charlie M							
Poznanski,Joshua							
Reida,Reanne N							
Reidy,Macoy M							
Relan,Jennifer							
Richardson,Jake							
Russell,Lucas S							
Schneider,Cade W							
Shah,Dhairya							
Sullivan,Tim Michael							
Sutton,Joshua T							
Svoboda,Benjamin C							
Thorson,Johnathan A							
To,Hoang Minh							
Torok,Jackson P							
Torres Leon,Hector							
Waggoner,Alex							
Wall,James Edgar							
Wegiel,Jeremy L							

AE 521 Small Report 5 Required Contents

Due Wednesday 18 October 8am to: kuaerodesign@gmail.com

Total Points: 50

Notes on Individual Assignment:
Note that the work to be performed for this report is to be done by an individual student. No other aid may be offered or given from other students or individuals outside of AE 521 course.

AE521_Report5_StudentLastName.docx *example: AE521_Report5_Snodgrass.docx*

AE521_Report5_StudentLastName.pdf *example: AE521_Report5_Snodgrass.pdf*

Note that you must turn in docx, .pdf and coding files

What follows is a specification for the minimum required contents report. Your report must be organized in this manner. You may, within each section, add sub-sections if you so desire. Each chapter must start with a statement of purpose, except the Introduction and the Summary/Conclusions chapters.

Report Title: AE 521 Report 5 Competition Design Choice, ConOps, Mission Specification & Profile

Cover - This is a good idea for both the .doc and .pdf files as it will be necessary when the file is printed to a hard copy. Name all team members.

Title Page - This page should be the first page of the report (if a cover is used, then it will be within the cover page).

Acknowledgments – Optional, make them real. Thank Mom/Dad/HS Teachers/Pets as you feel appropriate.

Table of Contents - The table of contents shall be structured as follows:

Table of Contents page

Page Numbering - The first section of the report containing the list of symbols, acknowledgment, list of tables and list of figures etc. shall be numbered with lower case Roman numerals. The body shall be numbered sequentially with Arabic numerals 1, 2, 3, etc. The Appendices shall be numbered with the letter of the appendix first followed by a dash and a page number: A-1, A-2, A-3; B-1, B-2, B-3 etc.

List of Symbols - You must include any symbols that are used in this report. You must give the names of the symbols and the units. After the main body of the symbols, you should include Greek symbols, then subscripts, followed by acronyms.

List of Symbols

Symbol	Definition	Units
c	chord	in
C	integration constant	lbf
$\overline{c}$	mean geometric chord	in
C'	derivative of integration constant with takeoff weight	~
c''	second derivative of chord with span	1/in
c_l	section lift coefficient	~
C_l	rolling moment coefficient	~
C_L	airplane lift coefficient	~
$c_{l\alpha}$	section lift curve slope	1/rad
$C_{L\alpha}$	airplane lift curve slope	1/rad
C_n	yawing moment coefficient	~
$C_{n\beta}$	yawing moment coefficient with respect to sideslip	1/rad
L	rolling moment	ft-lbf
M	Mach number, pitching moment	~, ft-lbf
N	yawing moment	ft-lbf
T	thrust	lbs
W	weight	lbs
etc.		

Greek Symbols

α	Angle of Attack	deg. or rad.
β	Sideslip angle	deg. or rad.
etc.		

Subscripts

δ_f	Due to flap deflection	---
TO	Takeoff	---
etc.		

List of Figures - List any and all figures that are found in the report along with the page they are found on.

List of Tables - List any and all tables that are found in the report along with the page they are found on.

Notes on Generated Codes and Plots
Any suitable code may be used (like Excel, MatLab, other coding language). The original code must be turned in with the homework. If Matlab or another computational code is used to generate figures in the body, include the code in a separate appendix, one appendix for each code used. If Excel is used, then include screen shots. Note that both Matlab and Excel (and any other computational codes) must be submitted separately as well.

1. Introduction:
Choose a competition design to analyze the rest of the semester and possibly in the Spring. Describe why you like this design better than the others. If you choose a design of your own construction, tell the reader why you want to work on this particular kind of aircraft.

2. Abbreviated Operating Statement (AOS)
Generate an AOS for your chosen design. Make it good and put some thought in it.

3. Concept of Operations (ConOps)
Generate a ConOps for your chosen design as was covered in class. Show all principal mission phases and interactions

4. Mission Specification
By using the results of Chapter 3, determine the local section lift coefficient, $C_l(y)$ assuming cruise speed. Plot your results showing local section lift coefficient, $C_l(y)$ on the vertical axis and semispan y(ft) on the horizontal axis.

5. Mission Profile
Generate a Mission Profile for your chosen design as was covered in class. Make SURE to do it in 3 dimensions with a CAD ribbon as was covered.

6. Summary and Recommendations
6.1 Summary
Summarize the contents of the report in a few sentences or (better) bullet points that are properly introduced with a grammatically complete sentence.

6.2 Recommendations
Make any real recommendations about the performance estimation. You must include at least one recommendation. Be sure to start with a phrase like: "This author recommends that:" or similar.

Airplane Design Series by Prof. Jan Roskam

Part I: Preliminary Sizing of Airplanes

Part II: Preliminary Configuration Design and Integration of the Propulsion System

Part III: Layout Design of Cockpit, Fuselage, Wing and Empennage: Cutaways and Inboard Profiles

Part IV: Layout Design of Landing Gear and Systems

Part V: Component Weight Estimation

Part VI: Preliminary Calculation of Aerodynamic, Thrust and Power Characteristics

Part VII: Determination of Stability and Control and Power Characteristics

Part VIII: Airplane Cost Estimation: Design, Development , Manufacturing and Operating

Airplane Design Series by Prof. Jan Roskam

Part I: Preliminary Sizing of Airplanes

Provides a rapid method for sizing an aircraft and determining:

- Gross take-off weight, Wto
- Empty Weight, We
- Mission Fuel Weight, Wf
- Maximum Take-off Thrust, Tto or Take-off Power, Pto
- Wing area, S
- Max, lift coefficients, clean, take-off and landing, C_{Lmax}, C_{Lmaxto}, C_{LmaxL}

Airplane Design Series by Prof. Jan Roskam

Part I: Preliminary Sizing of Airplanes

Mission Specification and Profile are Necessary to Start, Including:

- Payload with full specifications
- Range and/or loiter requirements
- Operating Altitudes
- Field lengths for take-off and landing
- Fuel reserves
- Climb requirements
- Maneuver requirements
- Certification base (FAR 23, 25, Experimental, LSA, Military etc.)

Top-Level Design Process: Military

Specific Required Operational Capability (ROC) Identified by Military

Contractor Identifies Need to Military

Initial Design and Trade Studies

Request for Proposal (RFP) Issued (Often Including Mission Specification and Profile(s))

ConOps Generated

Mission Spec. & Profile Refined

Objective Function Defined

Candidate Configurations Generated

Basic Modeling Performed, Each Configuration Scored

Suitable Candidates Selected

Preliminary Sizing

Preliminary Design

If all is well: Full-Scale Design & Development

Top-Level Design Process: Civil Aircraft

Market Niche Analyzed, Corporate Directions, National Goal Set, Board of Directors and/or Shareholders or Owners Determine Need for New Aerospace System

Initial Design and Trade Studies

Request for Proposal (RFP) Issued (Often Including Mission Specification and Profile(s))

ConOps Generated

Mission Spec. & Profile Refined

Objective Function Defined

Candidate Configurations Generated

Basic Modeling Performed, Each Configuration Scored

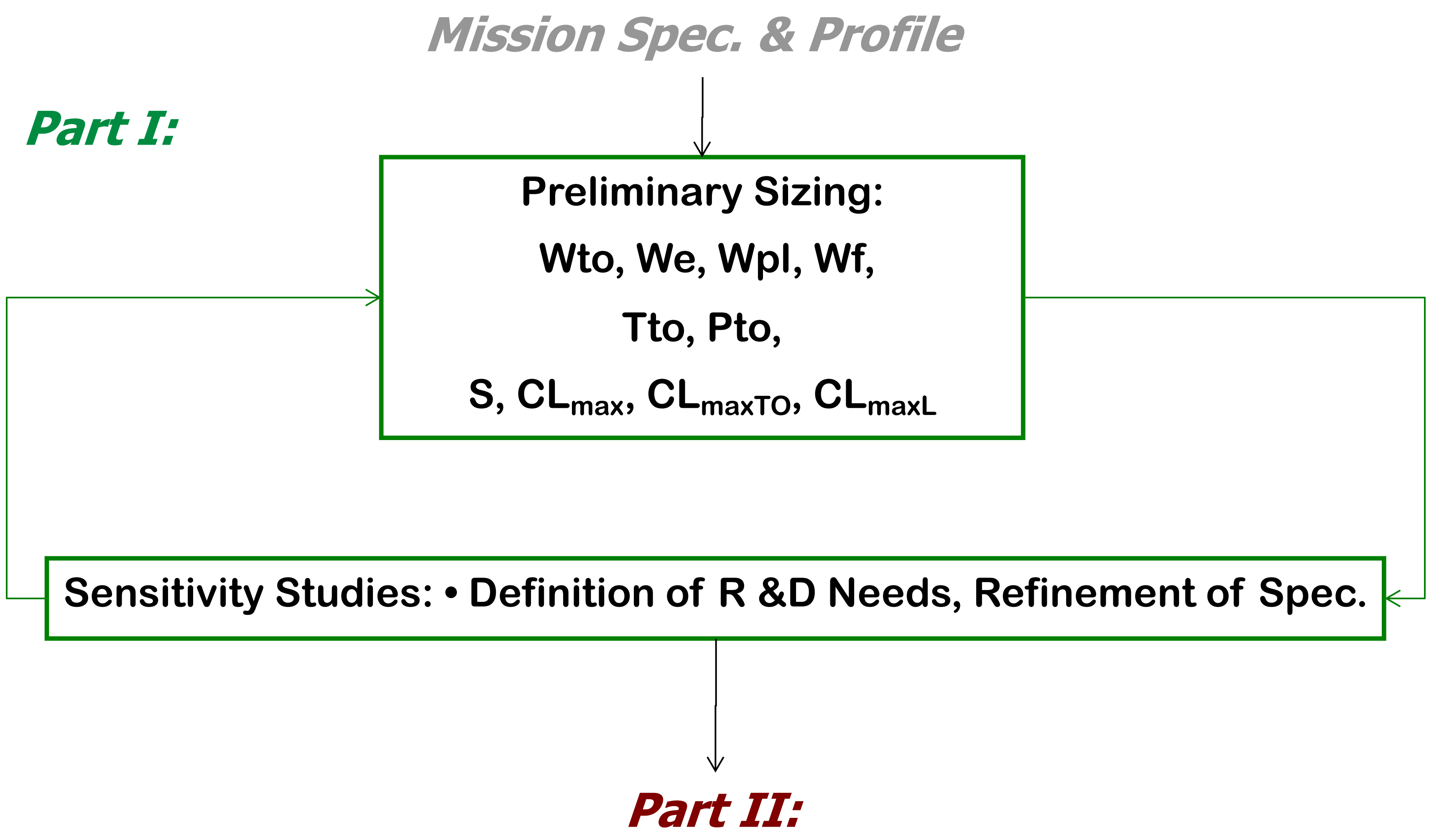
Suitable Candidates Selected

Preliminary Sizing

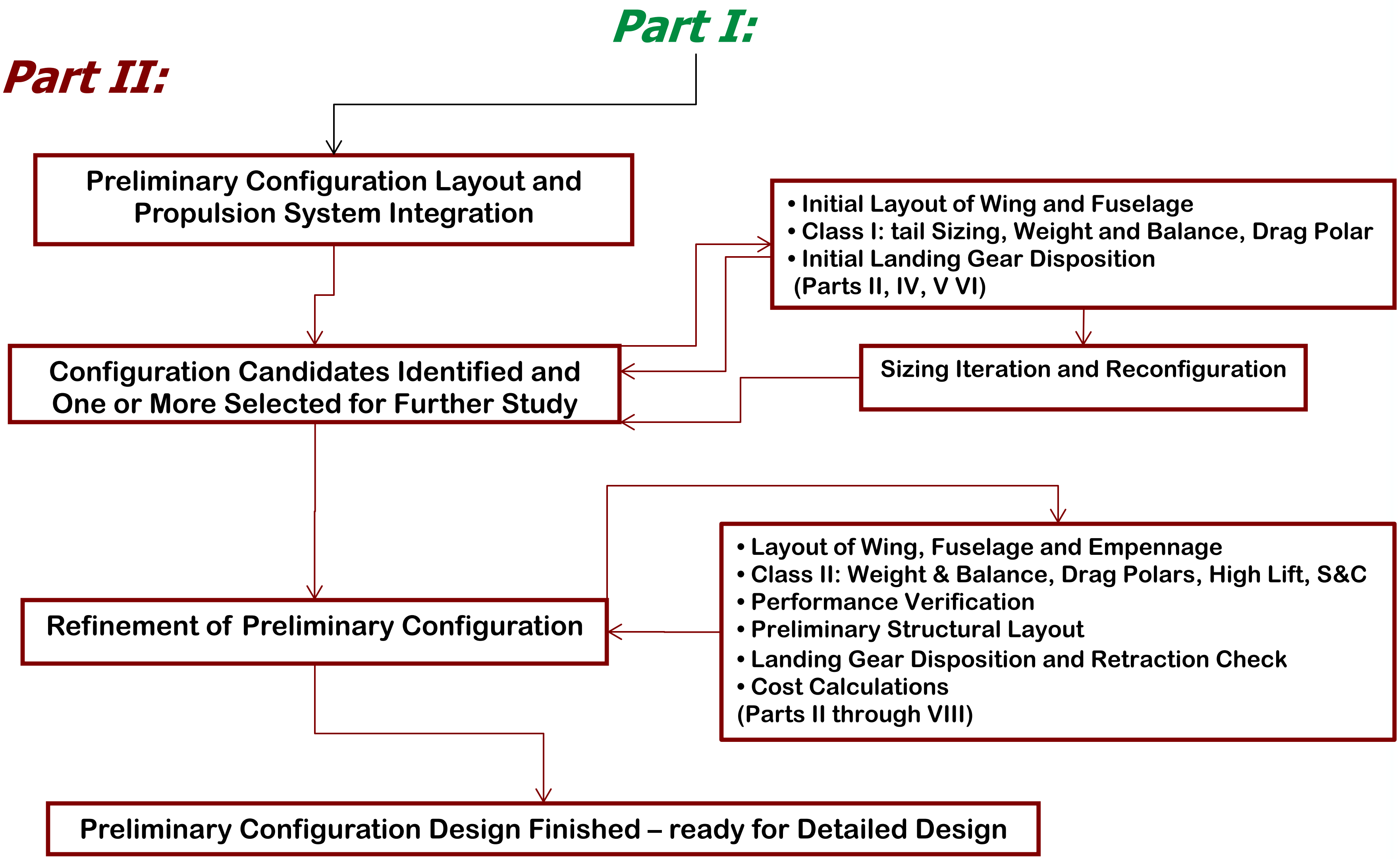
Preliminary Design

If all is well: Full-Scale Design & Development

Overall Aircraft Design Process from Mission Spec. & Profile



Overall Aircraft Design Process from Mission Spec. & Profile

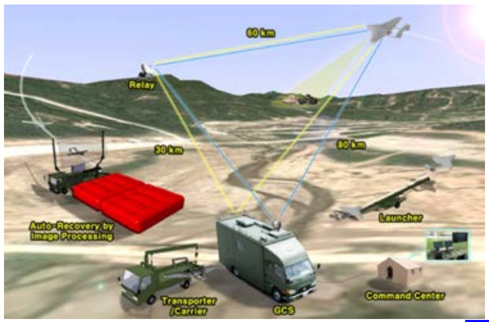


Top-Level Design Process: Civil & Military

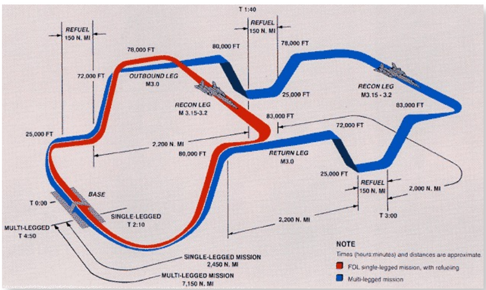
Decision-Makers Recognize Need for New Aerospace Aircraft System

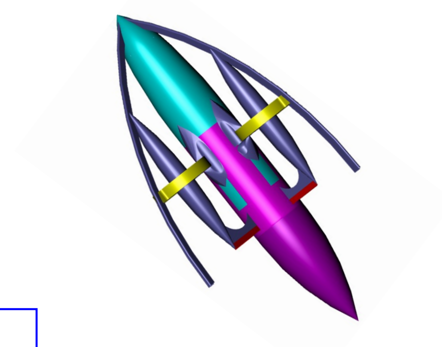
Initial Design and Trade Studies

Request for Proposal (RFP) Issued (Often Includes Draft Mission Specification and Profile(s))



1. ConOps Generated
2. Mission Spec. & Profile Refined
3. Objective Function Defined
4. Candidate Configurations Generated
5. Basic Modeling Performed, Each Configuration Scored
6. Suitable Candidates Selected
7. Preliminary Sizing
8. Preliminary Design



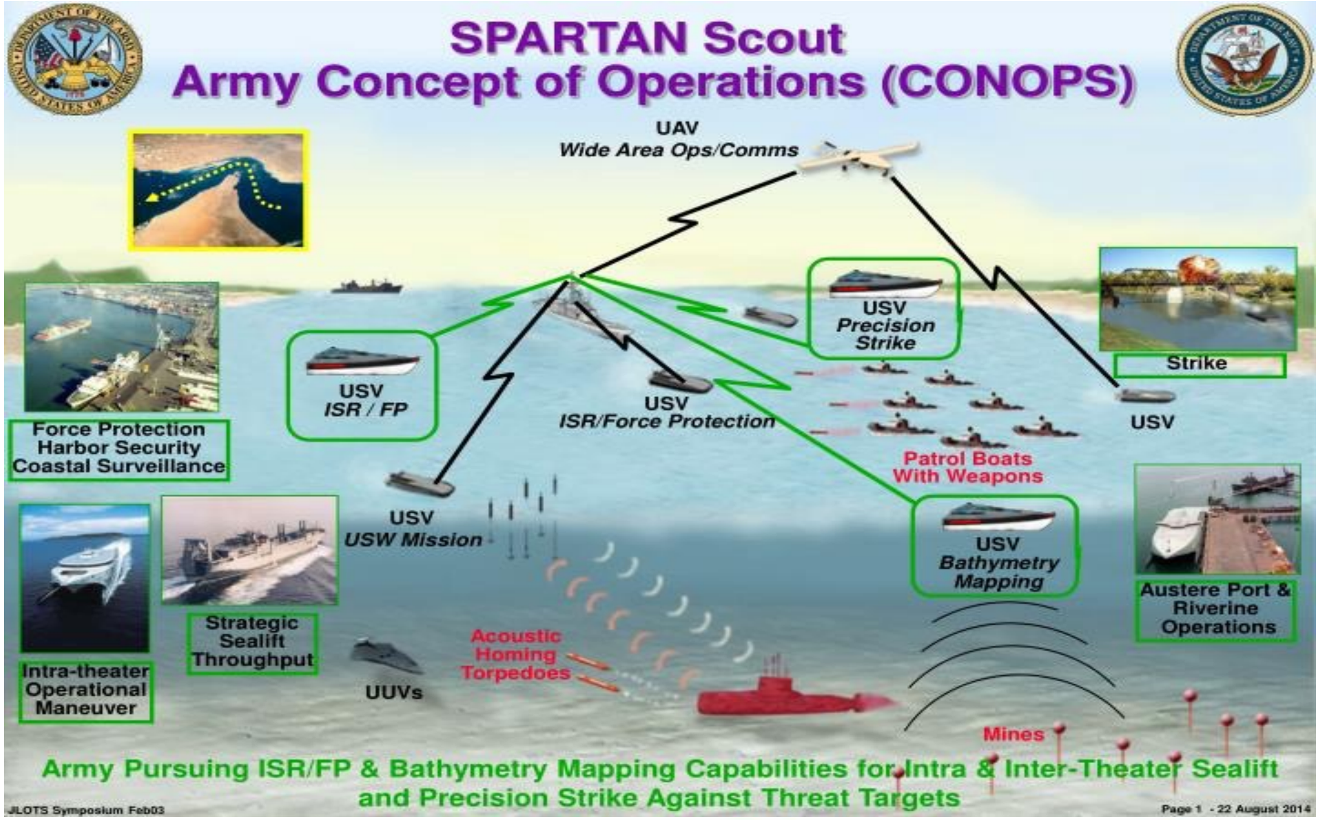


If all is well: Full-Scale Design & Development

Step 1: Concept of Operations

ConOps

Describes systems characteristics for a proposed system from a user's perspective. A CONOPS also describes the user organization, mission, and objectives from an integrated systems point of view and is used to communicate overall quantitative and qualitative system characteristics to stakeholders.



Step 2: Mission Specification & Profile

Mission Specification

Describes in words and with numbers the desired performance and constraints of the system as well as general characteristics to be optimized and requirements which must be met.

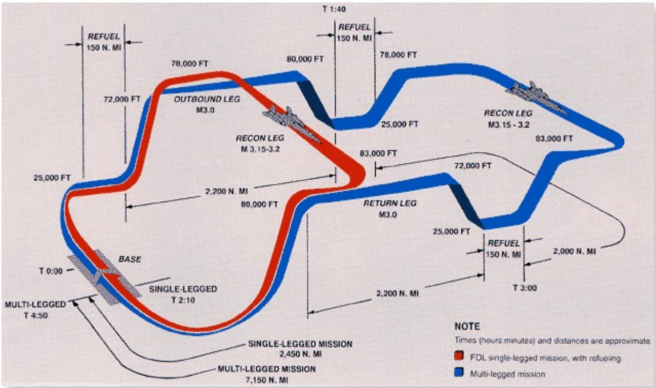
Table 1-1: Regional Jet Family Design Specifications [1]

	50-Seat Airplane	76-Seat Airplane
EIS	2030 for first model and 2031 for second model.	
Engines	Existing engine(s) or one that is in development that will be in service by 2029. Assumptions must be documented.	
Passenger Capacity (with 30- inch seat pitch)	50	76
Range	2,000 nmi	1,500 nmi
Cruise Mach Number	Minimum Mach 0.78 (Target: Mach 0.80)	
Approach Speed	Less than 141 kts	
Takeoff Length Over a 50 ft Obstacle (SL ISA + 18°F day)	4,000 ft	6,000 ft
Landing Length Over a 50 ft Obstacle (SL ISA + 18°F day)	4,000 ft	6,000 ft
Distance to Climb Up	Less than 200 nmi	-
Initial Cruise Altitude	FL 320	-
Takeoff and Landing Altitude	5,000 ft above MSL (ISA + 18°F)	
Crew No.	2 pilots and at least 1 cabin crew member per 50 passengers.	
Pilot/Crew Weight	190 lbs.	
Baggage Weight per Pilot	30 lbs.	
Baggage Volume per Pilot	4 ft^3	
Passenger Weight	200 lbs.	
Baggage Weight per Passenger	40 lbs.	
Baggage Volume per Passenger	5 ft^3	
Seat Width	At least 17.2 inches (Target: 18 inches)	
Aircraft Cross-Section	Stand up height in aisle similar to competitive aircraft. Baggage compartments are serviced ergonomically. Aisle width of at least 18 inches.	
Wingspan	At most 36 meters (Target: < 24 m)	

Design Mission Requirements	
Crew	2 crew members (zero-zero ejection seats)
Range	Minimum 2,500 nmi (Ferry Mission)
Additional Considerations	Survivability measures (Low Observables) Complete missions currently feasible only with attack helicopters
Certifications	Critical technologies TRL 8 or above MIL-STD-516C and JSSGs
Performance Requirements	
Austere Field Performance	Take-off & Landing over 50ft obstacle ≤ 4000ft
Density Altitude of Austere Field	Up to 6000 ft
Runway Conditions	California Bearing Ratio of 5 (grass or dirt surfaces)
Service Ceiling	≥ 30,000ft
Minimum Cruise Speed	310 kts per the mission profile
Service Life	
Production Run Duration	Service Life of +25 years or 15,000 hours
Hourly Cost	Less costly than current market
Entry into Service	2025
Ordnance Requirements	
Payload	3000 lb. armament
Weapons Provisions	Integrated gun, ability to carry rail-launched missiles, rockets, and bombs (500 lb. max)

Mission Profile

Presents in a graphic format all of the major events and mission legs which make up the entire mission. Missile, munition and rocket mission profiles often include elapsed times.



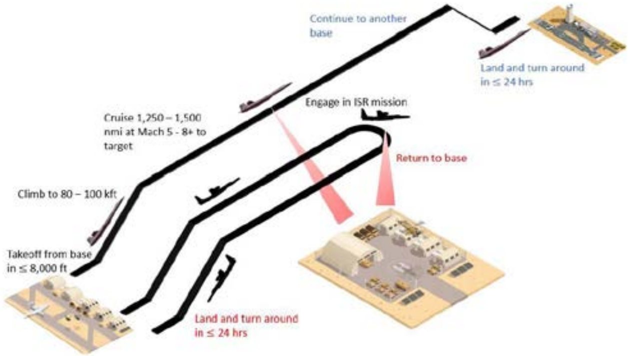


Figure 1.1.2: Endo-atmospheric mission profiles

Step 2: Mission Specification & Profile

Example Mission Specification – Attack Aircraft

Design Mission Requirements	
Crew	2 crew members (zero-zero ejection seats)
Range	Minimum 2,500 nmi (Ferry Mission)
Additional Considerations	Survivability measures (Low Observables)
	Complete missions currently feasible only with attack helicopters
Certifications	Critical technologies TRL 8 or above
	MIL-STD-516C and JSSGs
Performance Requirements	
Austere Field Performance	Take-off & Landing over 50ft obstacle ≤ 4000ft
Density Altitude of Austere Field	Up to 6000 ft
Runway Conditions	California Bearing Ratio of 5 (grass or dirt surfaces)
Service Ceiling	≥ 30,000ft
Minimum Cruise Speed	310 kts per the mission profile
Service Life	
Production Run Duration	Service Life of +25 years or 15,000 hours
Hourly Cost	Less costly than current market
Entry into Service	2025
Ordnance Requirements	
Payload	3000 lb. armament
Weapons Provisions	Integrated gun, ability to carry rail-launched missiles, rockets, and bombs (500 lb. max)

Step 2: Mission Specification & Profile

Example Mission Specification – Regional Jet

	50-Seat Airplane	76-Seat Airplane
EIS	2030 for first model and 2031 for second model.	
Engines	Existing engine(s) or one that is in development that will be in service by 2029. Assumptions must be documented.	
Passenger Capacity (with 30- inch seat pitch)	50	76
Range	2,000 nmi	1,500 nmi
Cruise Mach Number	Minimum Mach 0.78 (Target: Mach 0.80)	
Approach Speed	Less than 141 kts	
Takeoff Length Over a 50 ft Obstacle (SL ISA + 18°F day)	4,000 ft	6,000 ft
Landing Length Over a 50 ft Obstacle (SL ISA + 18°F day)	4,000 ft	6,000 ft
Distance to Climb Up	Less than 200 nmi	-
Initial Cruise Altitude	FL 320	-
Takeoff and Landing Altitude	5,000 ft above MSL (ISA + 18°F)	
Crew No.	2 pilots and at least 1 cabin crew member per 50 passengers.	
Pilot/Crew Weight	190 lbs.	
Baggage Weight per Pilot	30 lbs.	
Baggage Volume per Pilot	4 ft^3	
Passenger Weight	200 lbs.	
Baggage Weight per Passenger	40 lbs.	
Baggage Volume per Passenger	5 ft^3	
Seat Width	At least 17.2 inches (Target: 18 inches)	
Aircraft Cross-Section	Stand up height in aisle similar to competitive aircraft. Baggage compartments are serviced ergonomically. Aisle width of at least 18 inches.	
Wingspan	At most 36 meters (Target: < 24 m)	

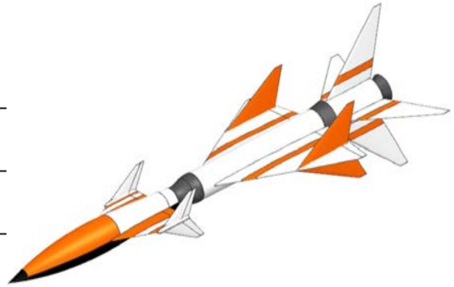
Step 2: Mission Specification & Profile

Example Mission Specification – Anti-Drone Aircraft

Target UAVs	Group 2 UAVs (threshold) – group 1 UAVs (objective)
Range	3 nmi (threshold) – 3.5 nmi (objective)
Service ceiling	3,000 ft (threshold) – 5,000 ft (objective)
Launcher + 1 missiles weight	< 40 lb
Launcher + 10 missiles weight	< 125 lb
Launcher + 10 missiles pack weight	< 50 lb (distributed across 3 people)
Interdiction rate	≥10 UAVs/hour
System storage without maintenance	≥ 10 years
Warhead arming distance (if used)	≥ 200 ft
Noise level withing 100 ft of launch	≤ 120 dBa
Launch acceleration	≤ 2 g's
Time to change payload (if used)	≤ 5 minutes
Production rate	200 missiles and 20 launchers a year for 10 years plus 15 missiles for development testing
System initial operating capability	≤ December 2027

Step 2: Mission Specification & Profile

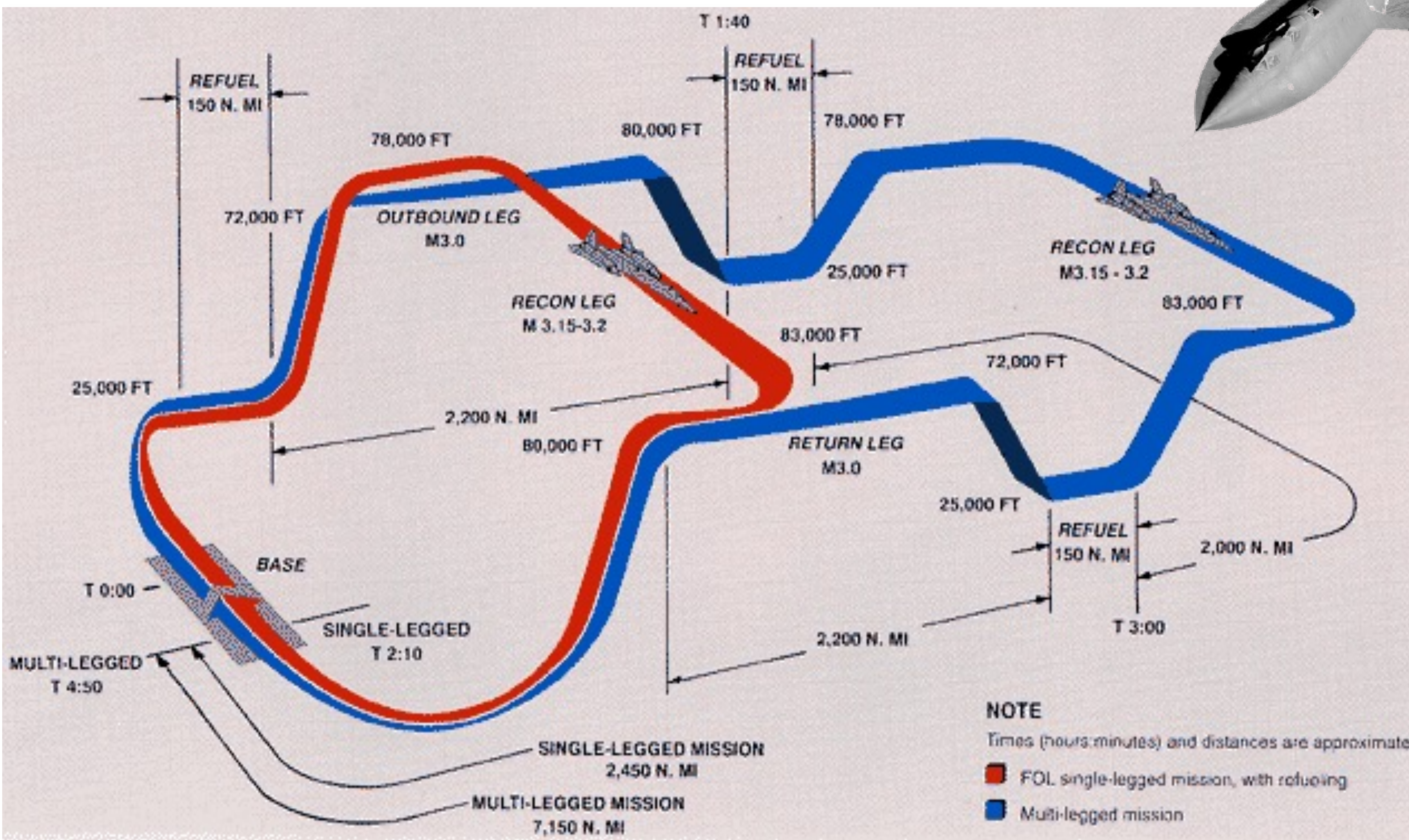
Example Mission Specification – Target Missile



Cruise Speed	Mach 5 (threshold) – Mach 8+ (objective)
Cruise Altitude	80 kft (threshold) – 100 kft (objective)
Range	2,500 nmi (threshold) – 3,000 nmi (objective) Capable of both round-trip and one-way missions
Runway Length	≤ 8,000 ft
Control	Remotely piloted unmanned system (autonomy permitted but not required)
Turn-around time	≤ 24 hr
ISR payload	≥ 3 × 3 × 12 ft ISR volume ≥ 1,000 lb ISR mass ≥ 2,000 W ISR power 2 downward-looking 12 in diameter transparent windows for EO/IR imagery contiguous to the payload Provide option for 1 × 2 ft RF antenna located on both sides of the fuselage with minimal occlusion from vehicle and heat flux
Production rate	10 aircraft and 2 ground control stations per year for 10 years plus 5 aircraft and 2 ground stations for development testing
System IOC	≤ December 2030

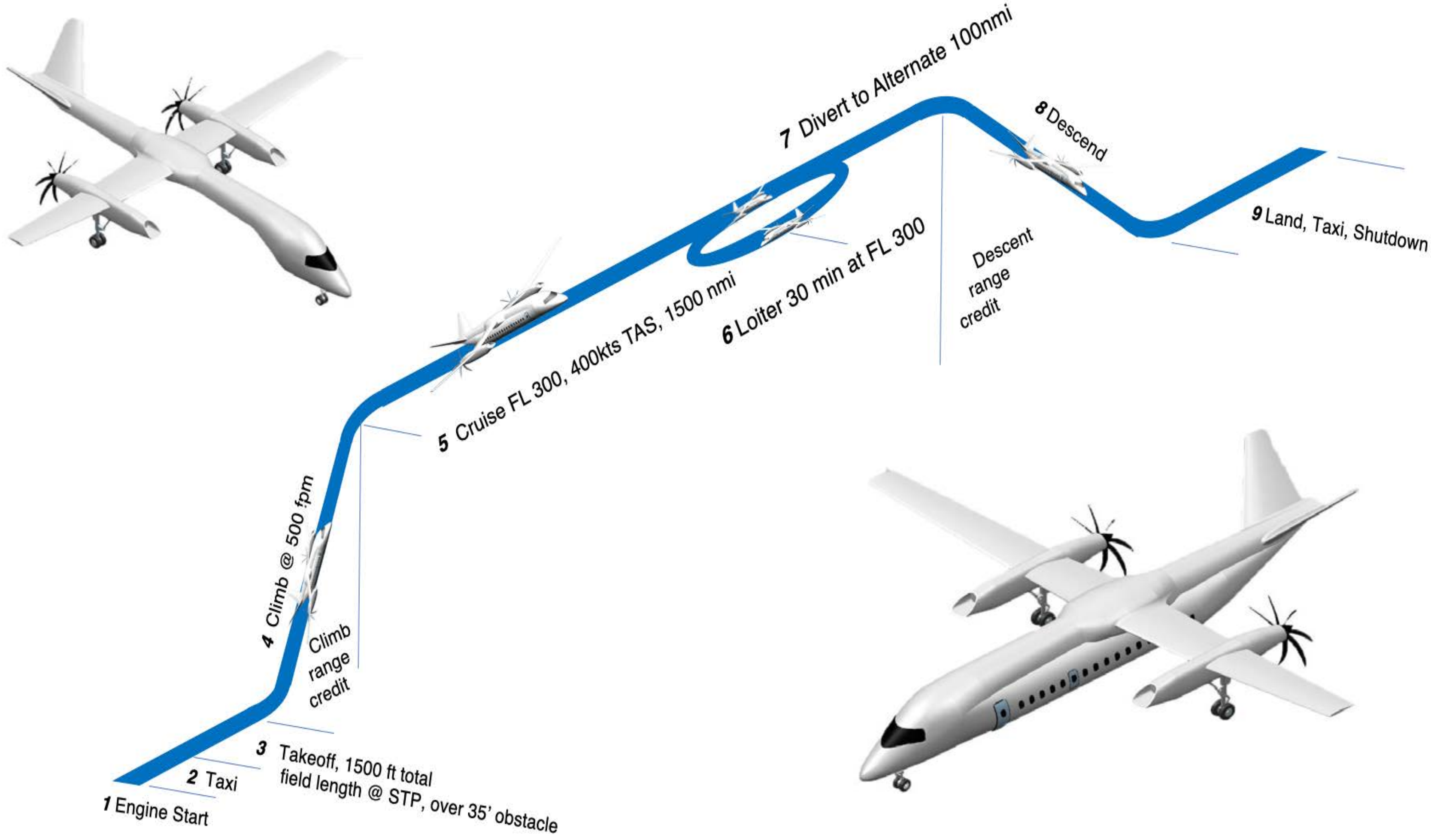
Step 2: Mission Specification & Profile

Example Mission Profile – SR-71



Step 2: Mission Specification & Profile

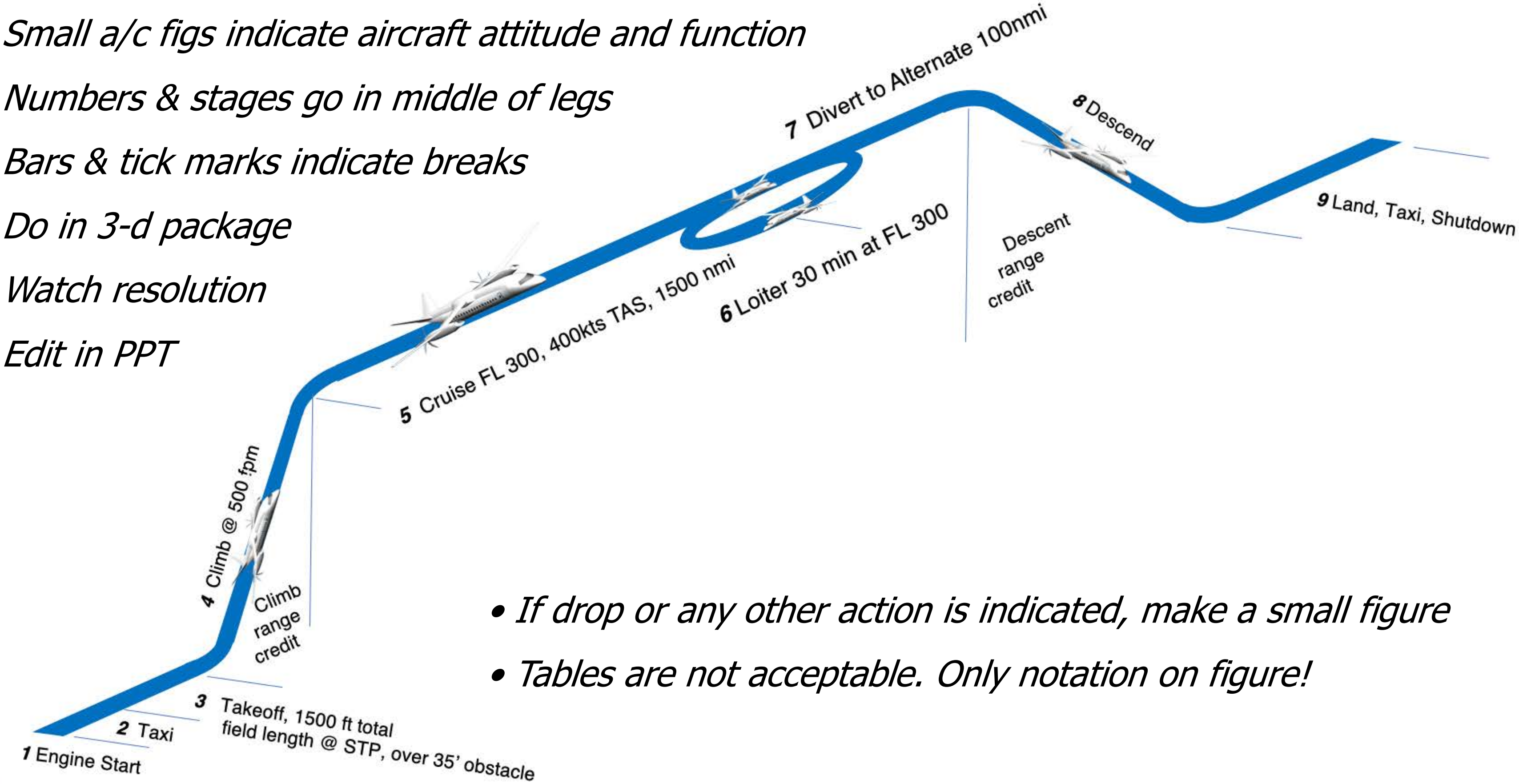
Example Mission Profile – Regional Turboprop



Step 2: Mission Specification & Profile

Example Mission Profile – Format

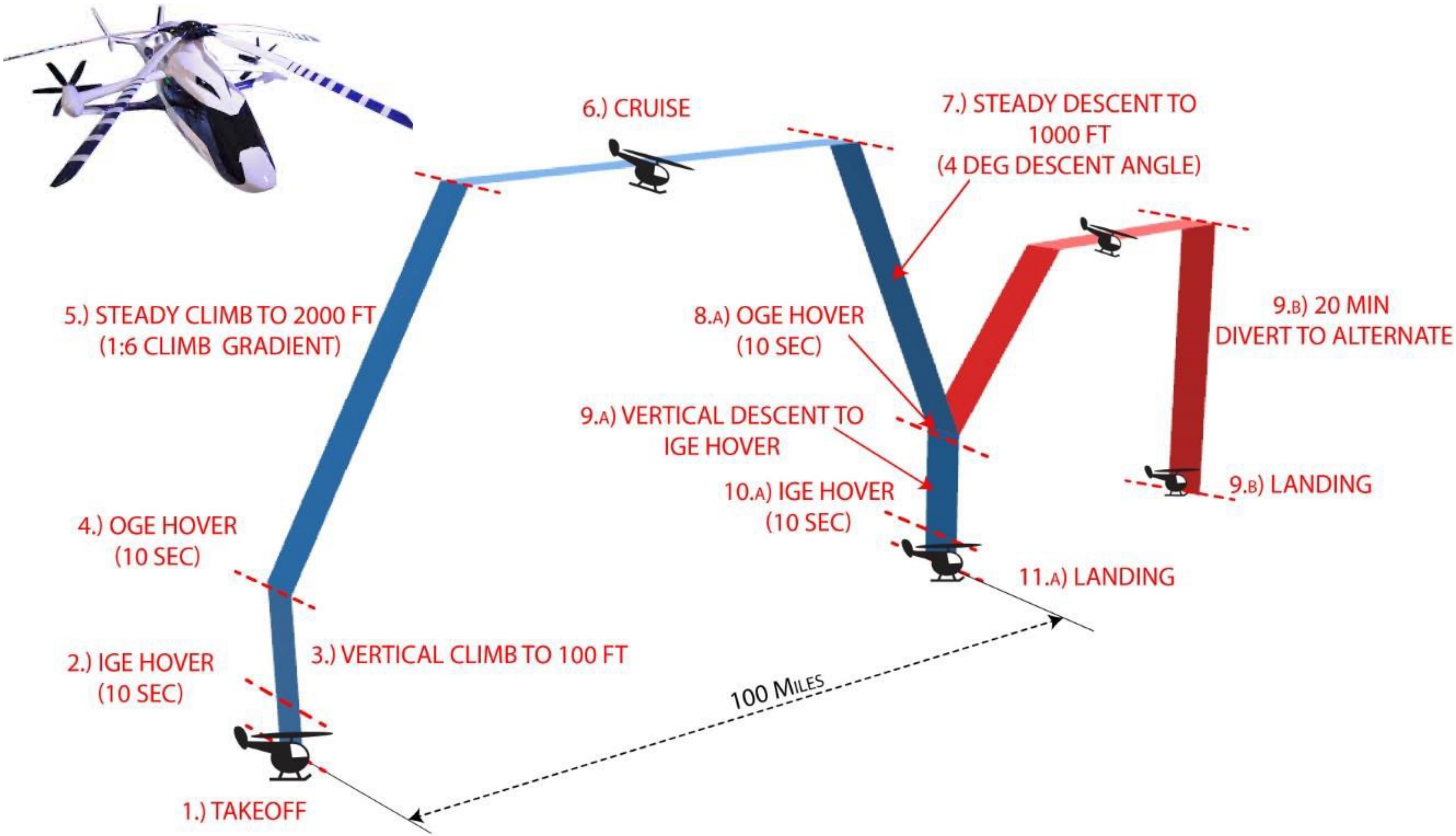
- *Construct as a 3-d ribbon using NX, then cut and edit further in PowerPoint or other package*
- *Ribbon indicates aircraft flight path & roll angle (esp. important for aerobatic & combat a/c)*
- *Small a/c figs indicate aircraft attitude and function*
- *Numbers & stages go in middle of legs*
- *Bars & tick marks indicate breaks*
- *Do in 3-d package*
- *Watch resolution*
- *Edit in PPT*



- *If drop or any other action is indicated, make a small figure*
- *Tables are not acceptable. Only notation on figure!*

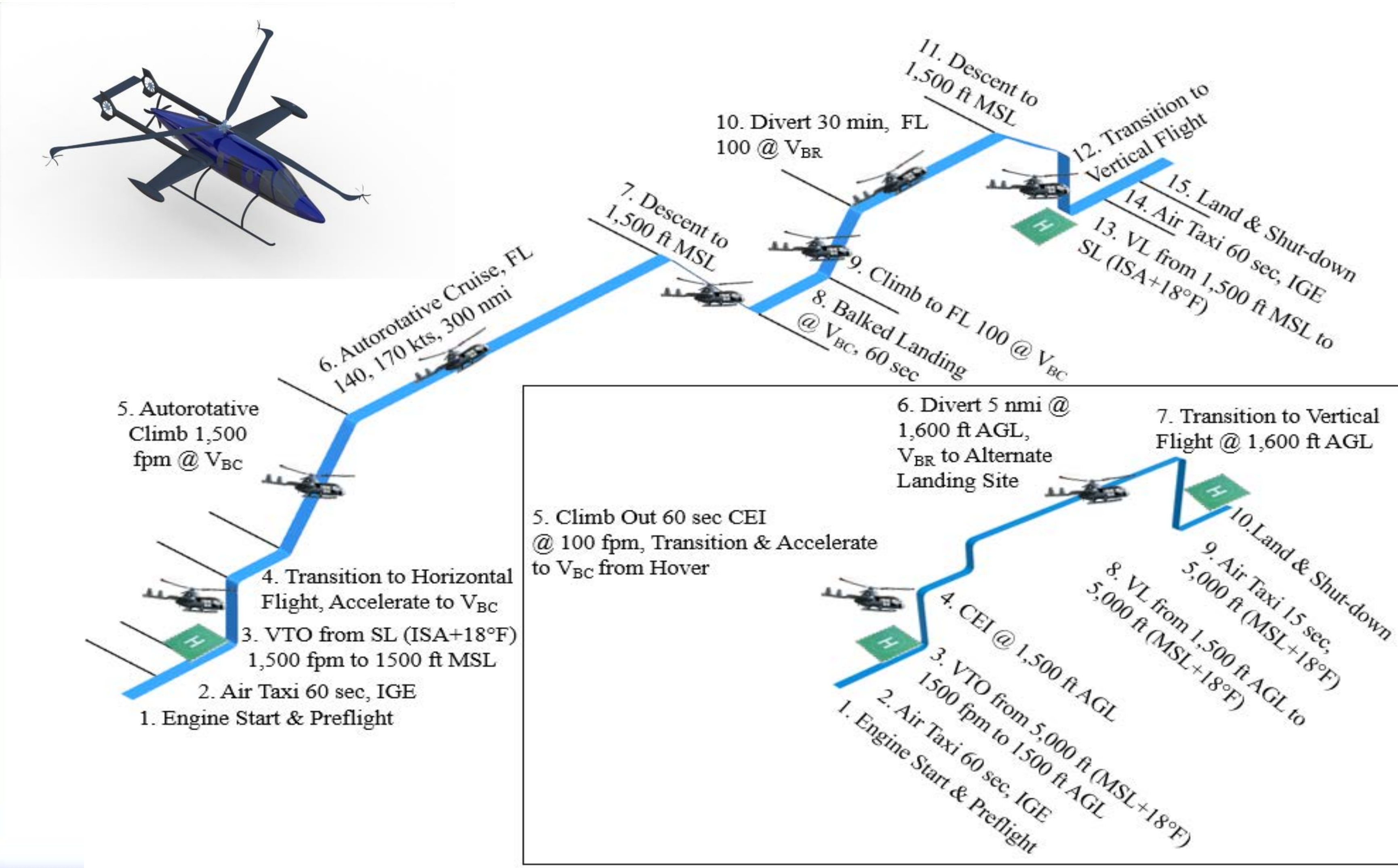
Step 2: Mission Specification & Profile

Example Mission Profile – Rotorcraft



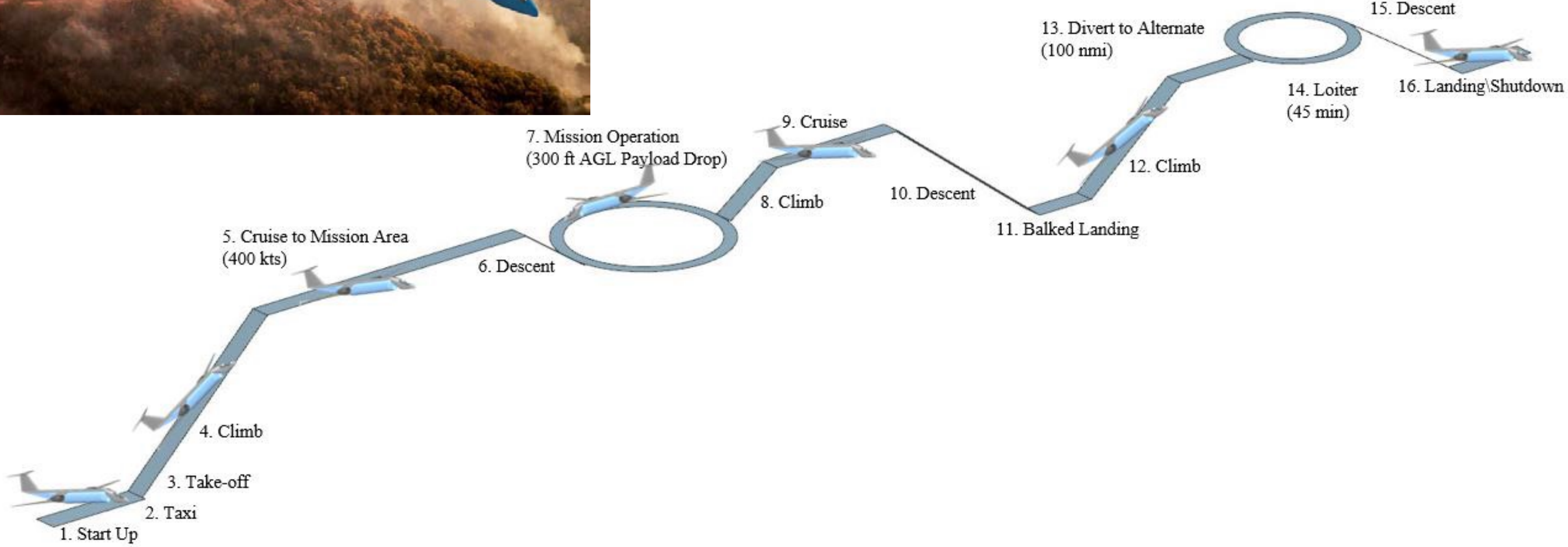
Step 2: Mission Specification & Profile

Example Mission Profile – Dual-Mode Hybrid STOL



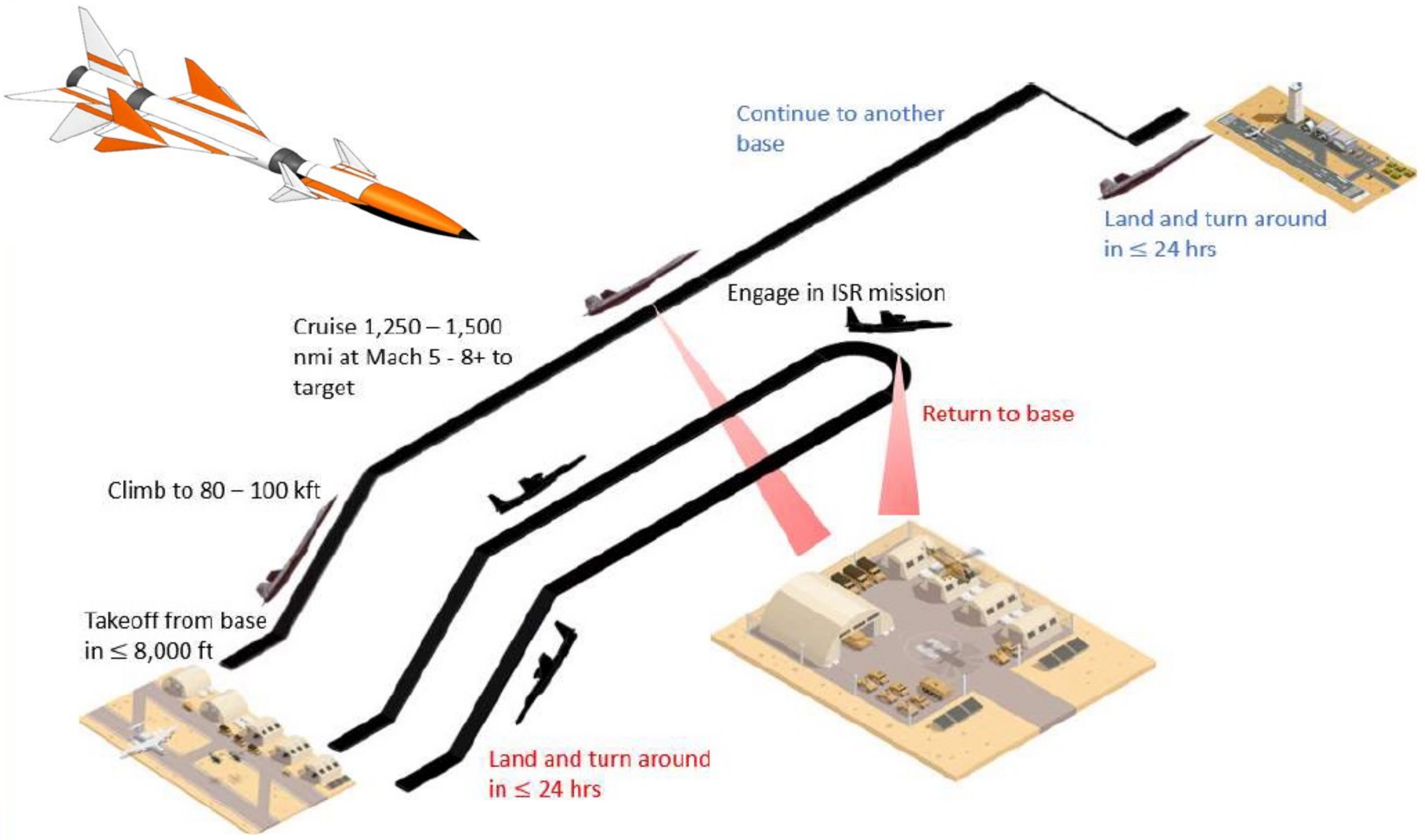
Step 2: Mission Specification & Profile

Example Mission Profile – Firefighter



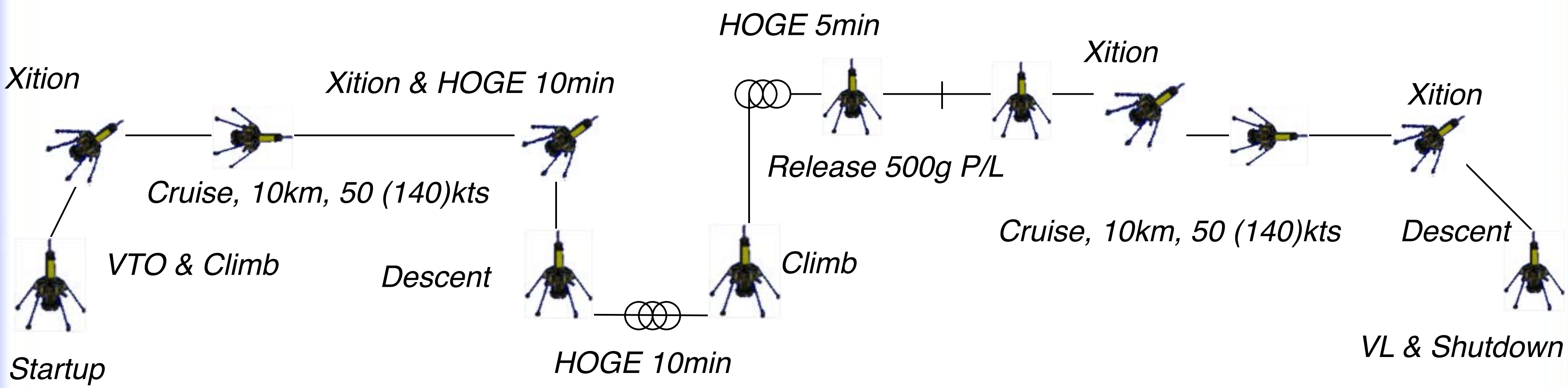
Step 2: Mission Specification & Profile

Example Mission Profile – ISR Aircraft



Step 2: Mission Specification & Profile

Example Mission Specification & Profile – XQ-138 (20 y/o line format)



Mission Specification:

- Max. gross weight: 6.8lb (3.1kg)
- Max.payload weight: 2.2 lb (1kg)
- All weather capable
- 12”/hr (31cm/hr) rain
- 25+ kt gust penetration
- Sensors: B/W 0.001 lux, Color 0.1 lux,FLIR
- Flight modes: 1st, 3rd person, fully autonomous w/waypoint nav.
- Sandstorm capable to 100kts
- Vmax 140kts for 1hr (blue sky)
- -40/100° F (38° C), 100% humidity
- Combat shotgun resistant @5m
- 15g MOUT wall strike
- Land + autostart