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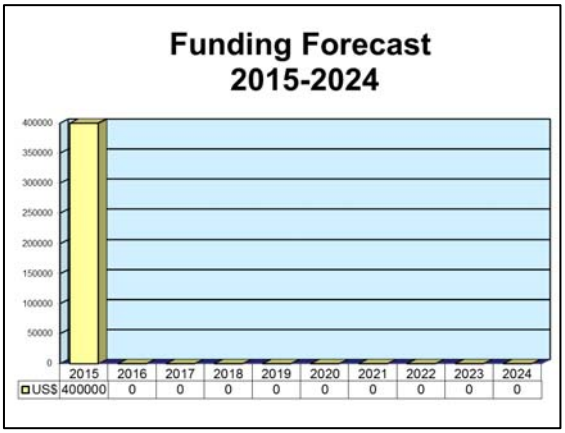
Integrated Sensor Is Structure (ISIS)

Outlook

- Airship risk-reduction studies and production of a radar demonstrator will be completed in FY15
- All funding activities will cease, with no future production anticipated
- At least one system may be built, but details are confidential and will not be announced
- This report will be archived in 2016



Orientation

Description. ISIS is a joint DARPA and USAF project to develop a large radar sensor that is fully integrated into the hull of a stratospheric airship.

Sponsor

U.S. Defense Advanced Research Projects Agency (DARPA)
3701 N Fairfax Dr
Arlington, VA 22203-1714
Tel: + 1 (703) 526-6630
Website: http://www.darpa.mil

Status. DARPA and USAF developmental project.

Application. The ISIS project addresses the United States' need for persistent, stratospheric, wide-area surveillance.

Contractors

Prime

Lockheed Martin Mission Systems and Training - Akron	http://www.lockheedmartin.com/us/mst.html, 1210 Massillon Rd, Akron, OH 44315 United States, Tel: + 1 (330) 796-2800, Fax: + 1 (330) 796-3274, Email: cary.j.dell@lmco.com, RDT+E (Advanced Material Technology)
Raytheon Space and Airborne Systems	http://www.raytheon.com, 7408-7412 Brent Way, McKinney, TX 75070 United States, Email: SAS_Comms_PA@raytheon.com, RDT+E (Radar Antenna)

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Integrated Sensor Is Structure (ISIS)

Technical Data

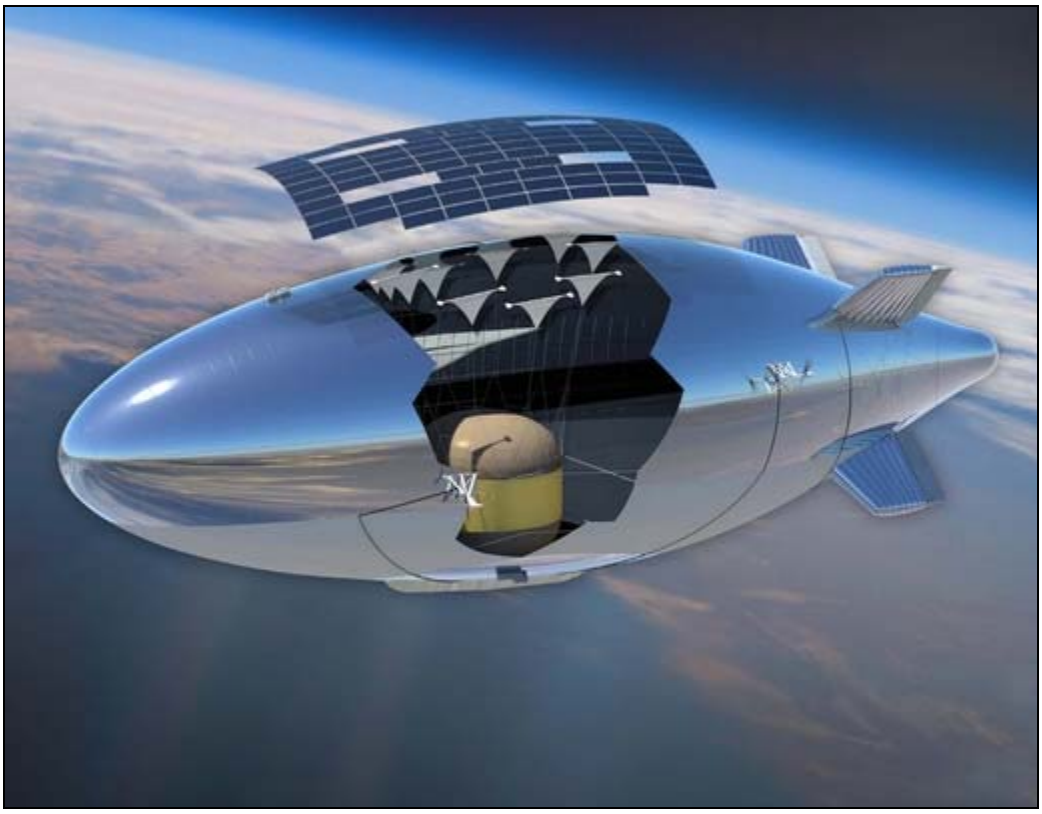
Design Features. The Integrated Sensor Is Structure (ISIS) is a United States DARPA and Air Force project to develop an aerostat system whose skin is the platform's sensor. Specifically, the ISIS project is developing an enormous radar antenna that would be fully integrated into the hull of a stratospheric airship. DARPA intends for the radar system to provide the United States with persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments.

The radar will achieve capability improvements over typical radars by melding a large aperture antenna and high-energy density components into a highly integrated, lightweight, multipurpose airship structure. This will erase the distinction between payload and platform, making for a far more efficient package.

The project personnel are developing systems that enable simultaneous airborne moving target indicator and ground-based moving target indicator capability. One of the project's other main focuses is on reducing the weight and volume of radar systems, and developing key technologies such as high-energy-density batteries, electronic circuits on thin-film barrier materials, advanced multipurpose airship hulls, and regenerative fuel technologies.

DARPA awarded Raytheon a contract to develop a radar antenna that is about 300 feet (90 m) long and weighs between 4,000 and 6,000 pounds (1,800 and 2,700 kg).

DARPA states that ISIS will have the capability to track cruise missiles with an air moving target indication range of 600 kilometers (373 mi) and dismounted enemies with a ground moving target indication range of 300 kilometers (186 mi). ISIS will have an airspeed of 60 knots sustained and will be capable of a 100-knot sprint. The entire system will have an approximate life-cycle of 10 years of autonomous, unmanned flight.



Integrated Sensor Is Structure (ISIS) Rendering

Source: Lockheed Martin

Program Review

'Smart Skins'

Study of the Integrated Sensor Is Structure system began in 2004 at the Defense Advanced Research Projects Agency. The ISIS project is tasked with developing a sensor that can be bonded to the hull of an unmanned airship. Engineers will create an active electronically scanned array (AESA) radar so thin that it can be bonded to an aircraft's hull and even form part of the skin; hence the nickname "smart skins." Analysts believe the technology has the potential to equip a wide variety of platforms. For now, designers see the most benefit in equipping a large airship.

The airship will give military leaders an almost constant surveillance asset, as it will be able to stay in the air much longer than a conventional aircraft. Also, the size of the airship allows the aperture to spread out over a relatively vast distance. The radar's enormous size will enable it to gather information at long ranges and with extremely high resolution.

Cold Temperatures – High Altitude

The project reached a major milestone in 2006 when contracts were awarded to Raytheon and Lockheed Martin to begin development of the radar antenna and the airship. Raytheon was awarded an $8 million contract to develop an AESA radar antenna that will be bonded to the hull of an airship. The antenna will transmit on the UHF and X-band frequencies. The radar will derive its exceptional abilities from its large size. It will likely take up almost the entirety of the airship's hull. Raytheon will also devise a means of bonding the radar to the hull. The bonding will need to be able to withstand many stresses, including -112°F (-80°C) temperatures.

Under a $10 million contract awarded in 2006, Lockheed Martin further developed advanced material technology and next-generation hull material for a stratospheric airship. The airship will operate at approximately 70,000 feet (21,500 m). Lockheed Martin focused on the strength-to-weight and life-expectancy metrics plus performance requirements such as shape, hull radius, environmental effects, and reliability.

MITRE reports that it has been providing technical support to DARPA from the beginning, including provision of power generation and storage systems, radar systems analysis, development and life-cycle cost analysis, and provision of electronic systems. (MITRE is a not-for-profit organization that operates research and development centers sponsored by the federal government.)

DARPA is working on a number of ISIS initiatives. These include designing and simulating new radar modes to track targets in clutter and to detect rockets, artillery, and mortars as well as dismounted ground targets. The project will also design, build, and demonstrate a fully operational scaled flight system.

Smart Skin Technology a Decade Away

The primary application for the technology will be unmanned aerial vehicles (UAVs), but the technology is extremely versatile and could equip platforms as small as a recon pod and as large and complex as a reconnaissance or cargo aircraft.

Integrated sensors offer many advantages over more traditional types of antennas. They allow any aircraft, such as a cargo aircraft, to be fitted for surveillance. The technology allows aircraft to have a much larger array, which increases radar range and resolution. For example, the entire wing of an aircraft could serve as the antenna. The area normally designated to hold the radar antenna could be utilized for something else, since the radar antenna would be on the outside of the aircraft. Another major benefit is that the integrated sensor, or "smart skin," would replace the need for a radome, improving aerodynamics.

According to MITRE, the unmanned ISIS airship, which measures 450 feet in length, will soar 70,000 feet above Earth for up to 10 years. Hovering in the stratosphere, safely out of range of most surface-to-air or air-to-air missiles, ISIS is designed to provide "unsurpassed" situational awareness with a surveillance range of 187 miles for individuals on the ground and 373 miles for advanced cruise missiles.

The development of smart skins is seen by many as the next advancement in radar technology. Experts believe it will be at least 10 years before ISIS technology becomes available to users. Over that time, DARPA is expected to spend nearly $765 million on development. There is a great deal of risk involved in developing any new technology, leading to the possibility that this capability may never come to fruition.

Weight Reductions

Aviation Week & Space Technology reported in May 2009 that during the first two phases of ISIS, the hull weight was reduced from 400 grams/square meter for traditional woven material to 100 grams/square meter. The hull is currently a laminate. Additionally, the radar aperture weight has been reduced from 20 kilograms/meter to 1.8 kilograms/meter. This was

Integrated Sensor Is Structure (ISIS)

done by using cell phone technology for the lightweight transmit/receive modules. The T/R modules operate at very low power and do not require cooling.

In April 2009, DARPA selected Lockheed Martin as the systems integrator and Raytheon as the radar developer for Phase 3. The contract is valued at nearly $400 million. The Lockheed Martin-led team will design, build, and flight-test a one-third-scale airship featuring a Raytheon radar. The flight test system will operate on station for 90 days; then several key components will be demonstrated over a period of one year. Raytheon announced that during the second quarter of 2009, its Space and Airborne Systems business had allocated $110 million for the ISIS radar project.

DARPA says the subscale system will consist of a roughly 100-square-meter X-band radar system and an approximately 600-square-meter UHF-band system. The X-band portion is about half the size of a roadside billboard and the UHF system is roughly the size of a soccer field.

In March 2009, *Inside the Air Force* reported that flight demonstration was scheduled for FY13. Following this, the Air Force will determine future acquisition needs.

FY09 Accomplishments

Among FY09 accomplishments, the ISIS team designed a radar resource controller for the dynamically assigned aperture. Additionally, the team developed and demonstrated the calibration and compensation subsystem and demonstrated large-scale critical integrated subsystems. Finally, ISIS team members conducted a system requirements review of the demonstration system.

ISIS Phase 3 Award

DARPA's ISIS project involved three developmental phases. Phase 1 involved a feasibility study, and during Phase 2, contractors developed system designs and critical technologies.

As discussed above, in April 2009, DARPA selected Lockheed Martin as the systems integrator and Raytheon as the radar developer for ISIS Phase 3. ISIS Phase 3 includes demonstration system design, large-scale integration, high-fidelity flight-test simulation, demonstration system build, and flight demonstration.

FY10-FY12 Objectives

In FY10, ISIS team members conducted the Preliminary Design Review of the demonstration system and conducted radar system operational modeling and simulation. Other goals that were accomplished included the development and demonstration of flight dynamic controls in a lab environment, and large-scale manufacturing of prototypes and initial integration.

According to DARPA, during FY11, simulations were to be conducted to validate subsystem detail design. During the same time period, risk-reduction testing and demonstrations of integrated subsystems would be conducted. Also, contractors would be tasked with manufacturing the airship envelope and chamber-testing the dual-band RF apertures. Finally, the ISIS team was scheduled to conduct a Critical Design Review of the demonstration system.

In DARPA's FY12 budget, plans included integrating the airship hull and radar aperture structures; installing and performing pre-flight tests of the power, propulsion, and ballast systems; completing ground station development; and conducting the flight-test readiness review. Plans also called for the launch and transit of the airship to the on-station demonstration area.

MITRE reported in March 2010 that the Air Force and DARPA had signed an agreement to develop a small demonstration prototype by 2014.

Three Big Problems

MITRE has said developing a stratospheric, airship-based, autonomous unmanned sensor requires unique expertise in the areas of hull material, active-array antennas, and power systems.

The hull material has to be stronger and lighter and last longer than conventional hull material. Energy generation and storage present another significant design challenge. MITRE reports that ISIS includes novel power systems for the airship that are based on solar-regenerative power. Solar cells collect energy from the sun and create hydrogen and oxygen from water during the day. At night, the hydrogen and oxygen are recombined in the fuel cell, which releases energy that allows the airship to operate after dark. Fuel cells were chosen for energy storage since they offer the best mass-to-energy storage ratio when compared to batteries and other storage systems.

In January 2011, Lockheed Martin selected ATK to provide the ISIS thermal control subsystem. ATK will provide hardware that performs heat acquisition, heat transport, and heat rejection for two complete thermal systems. The baseline design for both systems is a pumped two-phase fluid loop that interfaces with large, lightweight radiator panels attached to the vehicle's power bay.

New Capabilities and Reduced Costs

According to a March 2010 paper by Dr. Regina Dugan, then director of DARPA, the ISIS program's airship is the size of a 15-story apartment building and operates on multiple frequencies. She also says, "These large unmanned airships promise to provide extremely long-range continuous surveillance, individual target tracking, and engagement guidance for all air and ground targets, to include extremely small cruise missiles and UAVs, insurgents and guerrilla forces, and small vehicles operating under foliage – capabilities not possible using existing or planned air or space assets."

Dugan added, "Logistically resembling a satellite, such a fully regenerative solar-powered airship may be able to provide decade-plus operation at significantly reduced costs compared to present systems. If successful, a single station-keeping ISIS near Karbala, Iraq, in 2000 would have afforded coverage of the Iraqi No-Fly Zone at less than 5 percent of the $1.4 billion Southern Zone operation and sustainment."

The range of potential applications is wide, from maritime surveillance to ballistic missile and homeland defense.

Funding

U.S. FUNDING

	FY13 AMT	FY14 AMT	FY15 AMT	FY16 AMT	FY17 AMT	FY18 AMT	FY19 AMT
RDT&E (DARPA)							
PE#0603286E - Advanced Aerospace Systems							
Integrated Sensor Is Structure (ISIS)	5.000	N/A	N/A	N/A	N/A	N/A	N/A

	FY14 AMT	FY15 AMT	FY16 AMT	FY17 AMT	FY18 AMT	FY19 AMT	FY20 AMT
RDT&E (USAF)							
PE#0305205F - Endurance UAVs							
Proj 675372 - Integrated Sensor Is Structure (ISIS)	1.000	-	-	-	-	N/A	N/A

The ISIS technology demonstration systems transitioned to the Air Force in 2013.

N/A = Not Available

Source: United States DARPA, FY15 Budget Estimates, RDT&E, Defense Wide, Volume 1, March 2014;
United States Department of the Air Force, FY16 Budget Estimates, RDT&E, Air Force, Volume 3, Part 2, February 2015

Contracts/Orders & Options

Contractor	Award ($ millions)	Date/Description
Raytheon	8	Aug 2006 – Contract from DARPA to develop an AESA radar antenna that will be bonded to the hull of an unmanned airship as part of the ISIS research project.
Lockheed Martin	10	Sep 2006 – Contract from DARPA to develop advanced material technology and next-generation hull material for a stratospheric airship under the ISIS research project.
Lockheed Martin	~400	Apr 2009 – DARPA selects Lockheed Martin as the system integrator and Raytheon as the radar developer for ISIS Phase 3 program, awarding a $100 million increment of a total estimated $399.9 million. Team would build and flight-test a one-third-scale airship with radar. System would operate on station for 90 days. Work was expected to be completed in Mar 2013. According to Raytheon, Space and Airborne Systems booked $110 million on the ISIS radar program during the second quarter of 2009.

Integrated Sensor Is Structure (ISIS)

Contractor	Award ($ millions)	Date/Description
ATK	Undisclosed	Jan 2011 – Contract from Lockheed Martin. The scope of work to be performed on the ISIS program includes designing, developing, building, and testing hardware that performs heat acquisition, heat transport, and heat rejection for two complete thermal systems. The baseline design for both systems is a pumped two-phase fluid loop that interfaces with large, lightweight radiator panels attached to the vehicle power bay. Contract work will be performed at ATK's Beltsville, MD, facility.
Lockheed Martin	23.62	Nov 2011 – CPFF contract for prototype development.
Lockheed Martin	21.00	Jan 2013 – CPFF contract for prototype development.
Lockheed Martin	3.00	Dec 2013 – CPFF contract for prototype development.

Timetable

Month	Year	Major Development
Aug	2006	Raytheon awarded contract to develop ISIS radar
Sep	2006	Lockheed Martin awarded contract to develop airship fabric
	FY09	DARPA begins funding prototype
Apr	2009	Lockheed Martin awarded contract for ISIS Phase 3
	FY10	USAF begins funding development
	FY12	The prototype completes the design phase; the radar element is modeled and demonstrated
4Q	FY14	Radar demonstration and airship risk-reduction studies continue
	FY15	Radar element and airship materials demonstrations conclude, project ends

Worldwide Distribution/Inventories

ISIS is a **U.S. DARPA** and **Air Force** project. Only a small-scale demonstrator has been completed.

Forecast Rationale

Development funding for the Integrated Sensor Is Structure (ISIS) lighter-than-air stratospheric platform / radar will cease in FY15. There will be, at least officially, no ISIS production. However, at some point at least one aircraft may be built, details for which are confidential.

FY15 will see the culmination of all airship risk-reduction activities, and the production of a radar demonstrator. Project closeout activities will also begin and conclude. By FY16, the ISIS program will have reached its end.

This report will be archived in 2016.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR RDT&E FUNDING (in US$)												
Designation or Program		**High Confidence**				**Good Confidence**			**Speculative**			
	Thru 2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
MFR Varies												
Integrated Sensor IS Structure (ISIS) **<> United States <> Department of Defense <> DARPA / USAF Program**												
	388,106,000	400000	0	0	0	0	0	0	0	0	0	400,000
Total	388,106,000	400000	0	0	0	0	0	0	0	0	0	400,000