Ship to Shore Connector (SSC)

Design Development/Evolution

Joint SNAME SD-5 and International Hydrofoil Society
7 May 2015
SSC Program Description

**Need:** Landing Craft, Air Cushion (LCAC) functional replacement

**Platform:** Air Cushion Vehicle; same footprint as LCAC Service Life Extension Program (SLEP)

**Mission:** Land surface assault elements in support of Operational Maneuver from the Sea (OMFTS), at over-the-horizon (OTH) distances, while operating from amphibious ships and mobile landing platforms
SSC Program Requirements

• LCAC craft inventory (including SLEP) begins to degrade below the Required Operational Capability/Projected Operational Environment (ROC/POE) requirement beginning in 2015

• Formal requirements provided in Capabilities Development Document (CDD) with Key Performance Parameters (KPPs) approved by Joint Requirements Oversight Counsel (JROC) 10 June 2010

• Quantity: 73 SSC
  – 1 Test & Training (T&T) craft
  – 72 Fleet operational craft

• SSC received the Milestone B Acquisition Decision Memorandum approval on 5 July 2012
LCAC/SSC Operational Employment

- LCACs/SSCs transport weapons systems, equipment, cargo, and personnel of the assault element of the Marine Air/Ground Task Force from well deck equipped amphibious ships or the Mobile Landing Platform (MLP) to shore.
- Ships launch LCAC/SSC at distances over the horizon (25 nm or greater offshore) to prevent early detection of the landing force.
- Synchronized arrival of the equipment embarked on LCAC/SSC is essential to support the initial assault force.
- Rapid return to the amphibious ships and MLPs to pick up additional equipment is necessary to support the buildup of combat power ashore.
- SSC will be able to operate in NATO Sea State 3 (significant wave height of 4.1 ft), reach a high speed exceeding 40 knots, transport payloads of approximately 74 short tons, and operate over-the-beach clearing obstacles up to 4 feet.
During LCD, SSC will perform transport services during humanitarian assistance, NEO, among others.

Cross Deck of equipment and personnel occurs at sea prior to conducting offensive operations utilizing SSC supporting logistic operations between MSC shipping and shore.

Movement through the littorals and between platforms while communicating with the ARG or ATF, other ship to shore vessels and forces ashore.
Assumes craft are retired 10 yrs after being SLEP’d.

FY 20
~IOC~

FY 27
~FOC~

SSC Service Life 30 years

SSC CDD Requirement: 73 Craft
(1 Test & Training Craft; 72 Operational Craft)
Evolution of LCAC to SSC

<table>
<thead>
<tr>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>2010s</th>
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<tbody>
<tr>
<td>M60 Tank in USMC service</td>
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<td>M1A1 Tank in USMC service</td>
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**JEFF A / JEFF B**
- Prototypes leading to LCAC

**LCAC**
- Initial Craft Delivered December 1984
- Designed for 20-year service life
- Capable of carrying a 60-ton payload at speeds over 40 knots
- 91 LCAC fabricated

**LCAC (SLEP)**
- +10 years service life
- 47 out of 72 LCAC SLEPs delivered to date

**SSC**
- 1st Production craft to be delivered FY17
- Designed for 30 Year Service Life (without SLEP)
- 74 Short Ton payload & OTH assault from 25 nautical miles

**Improvements:**
- Increased reliability & availability
- Pilot/Co-pilot cockpit

*All Have Similar Footprint To Fit in Well Decks*
SSC Key Dates

- Initial Capabilities Document (ICD) signed: 18 October 2006
- Analysis of Alternatives (AoA): 28 November 2007
- Set Based Design (SBD) complete: 26 September 2008
- Program Support Review (PSR): 10 February 2009
- Preliminary Design Review (PDR): 26 March 2009
- Milestone A Acquisition Decision Memorandum: 21 May 2009
- Contract Design Review (CDR): 01 June 2010
- Capability Development Document (CDD) approved by JROC: 10 June 2010
- Early Operational Assessment (EOA): 01 November 2010
- DD&C RFP release: 20 May 2011
- Preliminary Design Review (PDR): 22 June 2011
- Program Support Review (PSR): 10 August 2011
- Focused Gate 5 to ASN(RD&A): 12 September 2011
- Final Cost Review Board: 15 September 2011
- Service Cost Position (SCP) memo NCCA: 16 September 2011
- Overarching Integrated Product Team (OIPT): 24 January 2012
- Final Independent Cost Estimate (ICE) from CAPE: 19 June 2012
- Milestone B DAB: 27 June 2012
- Milestone B Acquisition Decision Memorandum: 05 July 2012
- DD&C Contract Award: 06 July 2012
- Integrated Baseline Review (IBR): 03-07 June 2013
- Planned Delivery of Test & Training Craft (LCAC 100): 28 February 2017
- Planned IOC: 24 August 2020
Design Overview
LCAC/SSC Comparison

- Length, Overall: 27.98 m (91.8 ft)
- Beam, Overall: 14.5 m (47.8 ft)
- Buoyancy Box Depth: 1.27 m (50 in)
- Design Load: 54.43MT
- Hull Material: 5456 Aluminum
- Engines: 4 – Vericor ETF40B at 3955 SHP each
- Power Generation: 2 – 60 kVA APUs
- Electrical Distribution: 400Hz
- Lift Fans: 4 – 63” diameter
- Propellers: 2 – 11.75’ diameter
- Shrouds: Aluminum
- Gearboxes: 8 – Single input, single output
- Bow Thrusters: 2 – Belt driven hood
- Shafts: Steel
- Flight Crew: 3

- Length, Overall: 27.98 m (91.8 ft)
- Beam, Overall: 14.71 m (48.25 ft)
- Buoyancy Box Depth: 1.42 m (56 in)
- Design Load: 67.13 MT
- Hull Material: 5083 Aluminum
- Engines: 4 – Rolls Royce MT7 at 5300 SHP each
- Power Generation (common electrical end): 2)150 kVA craft service generators; 2)85kVA APUs
- Electrical Distribution: 60Hz
- Lift Fans: 2 – 69” diameter
- Propellers: 2 – 11.75’ diameter
- Shrouds: Composite
- Gearboxes: 2 – Dual input, dual output
- Bow Thrusters: 2 – Gear driven modified hood
- Shafts: Composite
- Integrated Flight Control with Pilot/Co-pilot controls
- Flight Crew: 2
Evolution of LCAC to SSC

Designed for 30 Year Service Life (w/o SLEP)
Capable of carrying a 74 Short Ton payload
86 nm w/o refueling (at 35+ knots)

**IMPROVEMENTS:**
Increased reliability and availability
SSC Craft Design

• Government/Navy-led Preliminary and Contract Design; Industry Detail Design

• Addresses Fleet’s top 25 LCAC high maintenance drivers, thereby reducing maintenance and operational costs, and increasing craft availability

• Leverages LCAC Service Life Extension Program (SLEP) improvements
SSC Design Drivers

- **Geometric Constraints**
  - Operate from LPD 17, LSD 41, LSD 49, and LHD 1 wells
  - Sets length and beam same as LCAC

- **Carry 74ST payload in 4.1ft Significant Wave Height (SWH) and 100° F for 86nm**
  - Sets required engine power

- **Use available engines**

- **CDD - Reliability, Availability, Maintainability**
  - LCAC top 25 issues

- **CDD - Total Ownership Cost**

Changes driven by increased payload and improved reliability and maintainability
SSC Improvements Over LCAC

• Pilot/Co-pilot reconfigured command module

• Increased range and payload
  • More efficient propulsion train
  • More powerful engines
  • Increased fuel efficiency
  • Advanced skirt

• Greater resistance to corrosion
  • More corrosion-resistant alloy used in construction
  • All internal spaces painted with high-solids, corrosion-resistant paints
  • Increased use of composites

• Reduced maintenance and operational costs

• Increased Reliability, Availability & Maintainability (RAM)
SSC Design Improvements

More lift + Lower Fuel Consumption + Less Maintenance

Simpler & More Efficient Drive Train/
One Gearbox per Side
(Fewer unique parts, less maintenance, higher reliability, all parallel axis, fewer efficiency losses, reduced training)

More Powerful Engines w/ Greater Fuel Efficiency & Digital FADEC
(Increased power for heavier SSC payloads, lower specific fuel consumption, more reliable FADEC)

Pilot/Co-Pilot Dual Controls
(Smaller flight crew + new C4N suite)

Composites
(Reduced weight and maintenance, corrosion resistance for propulsors, lift fan shrouds, bow thrusters, propulsion shafting)

Main Engine Geared Electrical Generators + APU & 60Hz Distribution Bus
(More fuel efficient and cost effective 60 Hz components, commonality with Navy ship electrical systems)

Gear Driven Bow Thrusters
(Increased reliability)

Sustained speed>40 kts
NATO Sea State 3 @ 100degF w/74 ST load

Interoperability
Operate from LPD 17, LSD 41/49, LHD/ LHA wells and MLP
Length same as LCAC

Aluminum Alloy (5083)
(Better corrosion resistance & immersion grade wet deck coating system)

Advanced Skirt
(Reduced weight, drag & fuel consumption)

Distribution Statement A: Approved for public release; distribution is unlimited.

UNCLASSIFIED
Machinery Design Improvements

**LCAC**
- 12 x Steel Shaft Segments
- 8 x Gearboxes
- 4 x 3955hp GTEs
- 400 Hz Electrical Dist Split Plant

**SSC**
- 4 x Composite Shaft Segments
- 2 x 85 kVA APUs
- 2 x Gearboxes
- 6 x Blade Props
- 4 x 5300hp GTEs
- 60 Hz Electrical Dist Parallel Plant
Simpler & More Efficient Drive Train - Few Parts/Easier to Maintain/Increase Ao

Utilize ICAS - Optimize Equipment Preventive Maintenance Periodicities

Improved HVAC – Increased Reliability/Lower Maintenance

AA 5083 & Advanced Internal Coating System - Increased Reliability/Lower Maintenance

Advanced Fire Fighting – no HALON

Improved HF Antennas – Improved Communications, Reliability, & Maintainability

Utilize Electric Actuators versus Hydraulic – Increased Reliability/Reduced Maintenance Burden

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Top 25 LCAC Maintenance Items

- Hull (Wet Deck) Plating Repair
- Skirt Side Fingers
- Radar
- Radios / Antennas
- Armor Windows
- Oil Cooler.
- Air Conditioners
- Sensors (Transducers / Chip Detectors)
- Rudder Actuator
- Cushion Vane Design / Corrosion
- Fire Protection - HALON Bottles - Fire Sensors
- Fuel / Lube / Hydraulic Oil Contamination
- Fuel Pumps
- Propeller Assembly.
- Prop Control Module
- Main Engine
- Lift Fan Blades
- APU Engine
- A/C Generator
- Propulsion Shroud Stators
- Exhaust Collectors
- Bow Thruster Bearings
- Engine Gearbox
- Transmission Shafting (S1-S10) Hardware
- Remote Controlled Circuit Breakers
LCAC Top 25
RMA Drivers Addressed

LCAC Lessons Learned
- Top 25 Maintenance Drivers
- Prototypes

Extensive use of composites

60 Hz Electrical Distribution System

AA 5083 & advanced internal coating system

Electrical-Hydraulic Actuators

Utilize ICAS & CBM to Optimize Equipment Preventive Maintenance Periodicities

Maintainability Demonstrations

Advanced Fire Fighting
PEAT – no HALON

Require Equipment & Craft-Level Reliability Growth Testing
Gear Driven Bow Thrusters

Simpler & More Efficient Drive Train

Gearbox Driven Generators

Improved HVAC

Simplified Window Arrangement – fewer unique parts

Improved HF Antennas – improved comms reliability
SSC Design Characteristics
More Lift + Lower Fuel Consumption + Less Maintenance

Advanced Skirt
Cargo Deck Sized for M1-A1 Tank
Pilot / Co-pilot Arrangement
Fuel Efficient Engines
Efficient Propellers
SSC Placemat

**DIMENSIONS**
- Length, Overall: 27.98m (91.80 ft)
- Length, Buoyancy Box: 24.52m (80.46 ft)
- Overall Beam: 14.71m (48.25 ft)
- Beam, Buoyancy Box: 13.31m (43.67 ft)
- Air draft on cushion: 8.05 m (26.40 ft) (nav mast folded)

**WEIGHTS (metric tons)**
- Full Load: 180.57
- SERVICE LIFE: 30 Years

**SUPPORT SHIP CAPACITY**
- LPD 17 CLASS: 2
- LSD 41 CLASS: 4
- LSD 49 CLASS: 2
- LHD 1 CLASS: 3
- MLP: 3
- LHA 8: 2

**WEAPONS**
- 2 MK93 Gun Mounts supporting:
  - M2-HB .50 cal machine gun
  - MK19 40mm grenade launcher
  - M-60/M240 7.62mm machine gun

**ELECTRICAL SYSTEMS**
- 2 x 150kVA gearbox driven generators 60Hz
- 2 x 85kVA APU 60Hz
- 60 Hz distribution system

**MANNING**
- Crew: 5
- Pilot / Co-pilot configuration

**PERSONNEL CAPACITY**
- 26 Troops Combat Equipped

**CARGO CAPACITY**
- Cargo Deck Area: 1671ft²/155.23M²
- Cargo Load: 67.13 MT (74 ST)

**BUILDING YARD**
- TEXTRON MARINE AND LAND SYSTEMS (TM&LS) New Orleans, LA

**NAVIGATION**
- Radar: Sperry BridgeMaster E, or equal
- INS & GPS: SAASM compliant EGI

**SURVEILLANCE**
- None

**COMMUNICATIONS**
- UHF/VHF/SATCOM: AN/ARC-210
- HF: AN/ARC-220
- EPLRS: AN/SRC-XX(1)

**FLIGHT/ENGINEERING CONTROL**
- ECS w/ ICAS based CBM
- Integrated Flight Control
- VME or VME/PLC Hybrid

**MACHINERY SYSTEMS**
- 4 x Gas Turbines @ 17,000 kW (22,800 hp) MIR; 15,600 kW (20,900 hp) MCR
- 2 x Controllable-pitch 6 bladed airscrews (3581 mm = 11.75 ft) in composite shrouds
- 2 x Dual input/Dual output gearboxes
- Composite shafting
- 2 x lift fans 164 psf
- 2 x bow thrusters 3890 lbs thrust
- C4N
- IFF: AN/APX-123

**CDD 10 JUNE 2010**
**UNCLASSIFIED**
Set-Based Design & Backups
SSC - Innovative Approach

- First ship design implementation of Set-Based Design (SBD)

- Government Design locks in major details
  - Increased payload and more severe environment
  - Improved maintainability and reliability
  - Optimized Total Ownership Costs (TOC)

- Builder does what he knows best
  - Design for producibility
  - Reduce Acquisition Cost
Set-Based & Preliminary Design Schedule

- Subsystem Trade Studies
- Integration Period
- Proposed Baseline Review
- PD-1
- PD-2
- Review
- CD Prep

- Apr 21
- Jun 21
- Aug 18
- Sep 26
- Nov 3
- Dec 19
- Jan 5
- Feb 20
- Mar 26
- May 1

- Design Space Brief
- Trade Space Parameters
- Trade Space Parameters
- Point Design Output
- Point Design Output
- Functional Baseline

- Preliminary Design Phase

Distribution Statement A: Approved for public release; distribution is unlimited. UNCLASSIFIED
Trade Space Definition & Element Partitioning

HSI
Element-Specific Exclusions:
Combination-Specific Exclusions:

Element-Specific Exclusions:

Little craft level impact parameters/options

Dominated Options

Infeasible Combinations

Dominated Combinations/Options

Failed Configurations

Balancing

Craft Evaluation

High Value Options

10-20 High Value Configurations

11 “Key” Design Parameters/13K+ Configurations

Recommended Design with Backups

Hull
Machinery
Auxiliaries
C4N
Performance (Skirt)

>125 Candidate “Key” Design Parameters

Trade Space Formalization & Reduction

SSC Implementation of SBD

Distribution Statement A: Approved for public release; distribution is unlimited.
Trade Space Reduction Progress

Trade Space Reduction

Candidate Vital PVs

LOG 10 (Option Count)


Formal Start of Reduction Efforts
Start of Integration
Craft Scoring
Balancing Checks

Vital PVs
LOG(# options)
Air Cushion Vehicle (ACV) Operation

- Principles that guide the development and operation of all aircraft apply to ACVs
  - Lift, thrust, gravity (weight), drag; centers of gravity/trim; directional stability
- ACVs ride on a cushion of air
  - When not on the air cushion, the LCAC/SSC rides (floats) on a buoyancy box
- The air cushion is generated by high volume fans on the ACV that force air downward under the craft. The air is contained by a flexible “skirt”
- Forward motion and directional stability are provided by propellers, rudders, and thrusters
- Proper placement of loads on the ACV is critical to the craft being able to get on cushion and maintain trim
- Fuel consumption during operation means the ACV must actively monitor and adjust trim
- Operations over land are impacted by terrain, slope, obstacles, and gaps/ditches that prevent contact of the skirt with the ground, cause abrasion or tearing of the skirt, or produce debris that is ingested into the engines/propellers/lift fans
LCAC/SSC Comparison

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<th>LCAC SLEP</th>
<th>Parameter</th>
<th>SSC</th>
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<td>Length, Overall</td>
<td>Same as LCAC</td>
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<tr>
<td>14.71 m (48.25 ft)</td>
<td>Beam, Overall</td>
<td>Same as LCAC</td>
</tr>
<tr>
<td>7.874 m (25.83 ft)</td>
<td>Height on-cushion</td>
<td>8.047 m (26.4 ft)</td>
</tr>
<tr>
<td>5.944 m (19.5 ft)</td>
<td>Height off-cushion</td>
<td>6.12 m (20.08 ft)</td>
</tr>
<tr>
<td>95.98 MT</td>
<td>Light Ship Weight</td>
<td>100.94 MT</td>
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<tr>
<td>54.43 MT</td>
<td>Design Payload</td>
<td>67.13 MT</td>
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<tr>
<td>156.37 MT</td>
<td>Full Load Weight</td>
<td>180.57 MT</td>
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<tr>
<td>5</td>
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<tr>
<td>3</td>
<td>Flight Crew</td>
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Changes driven by increased payload and improved reliability and maintainability