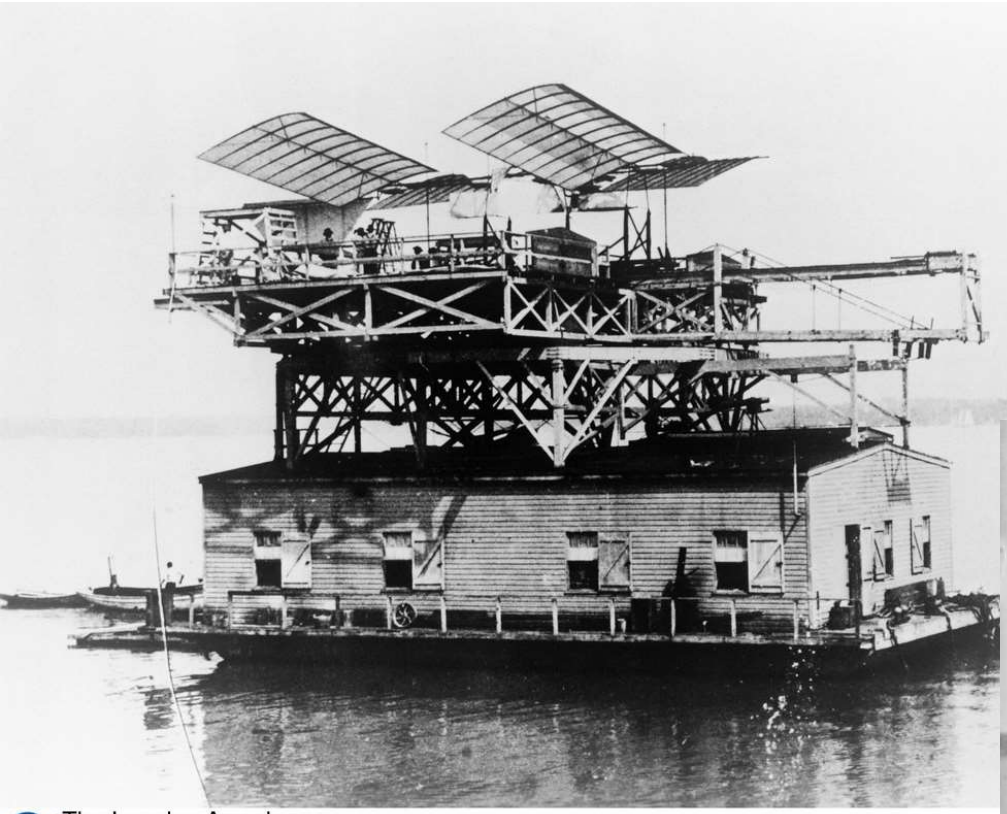
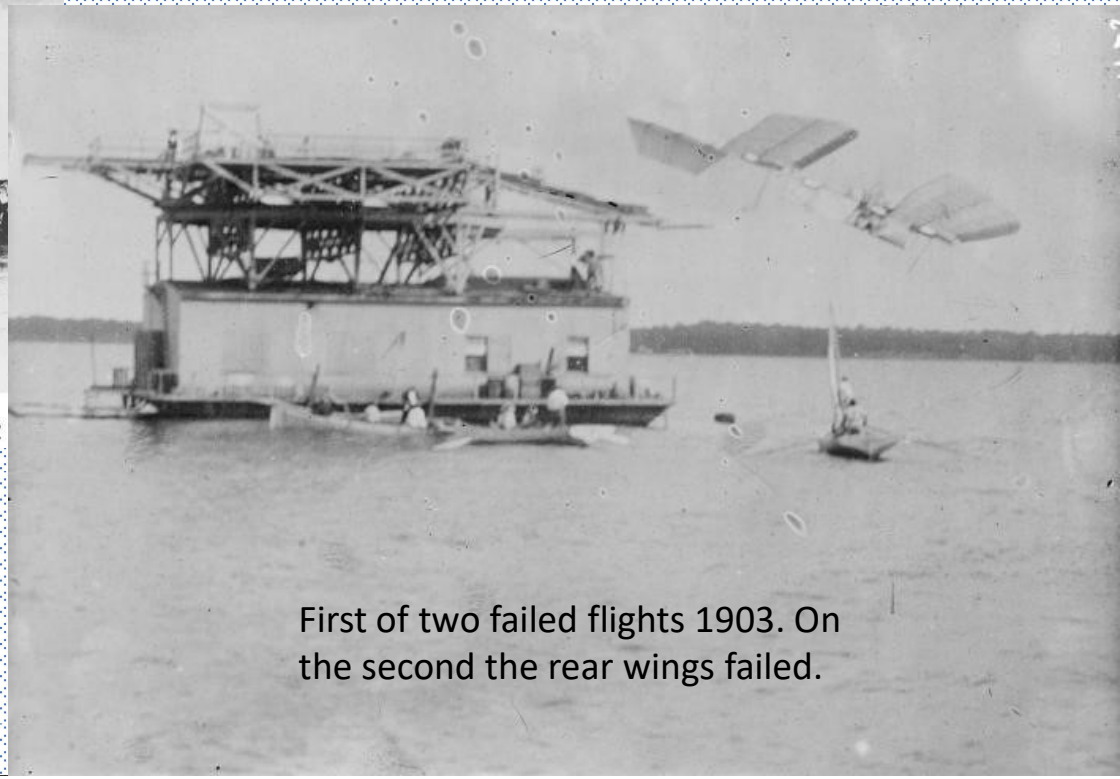
Catapult (and other) Assisted Launching

Langley – Spring Catapult

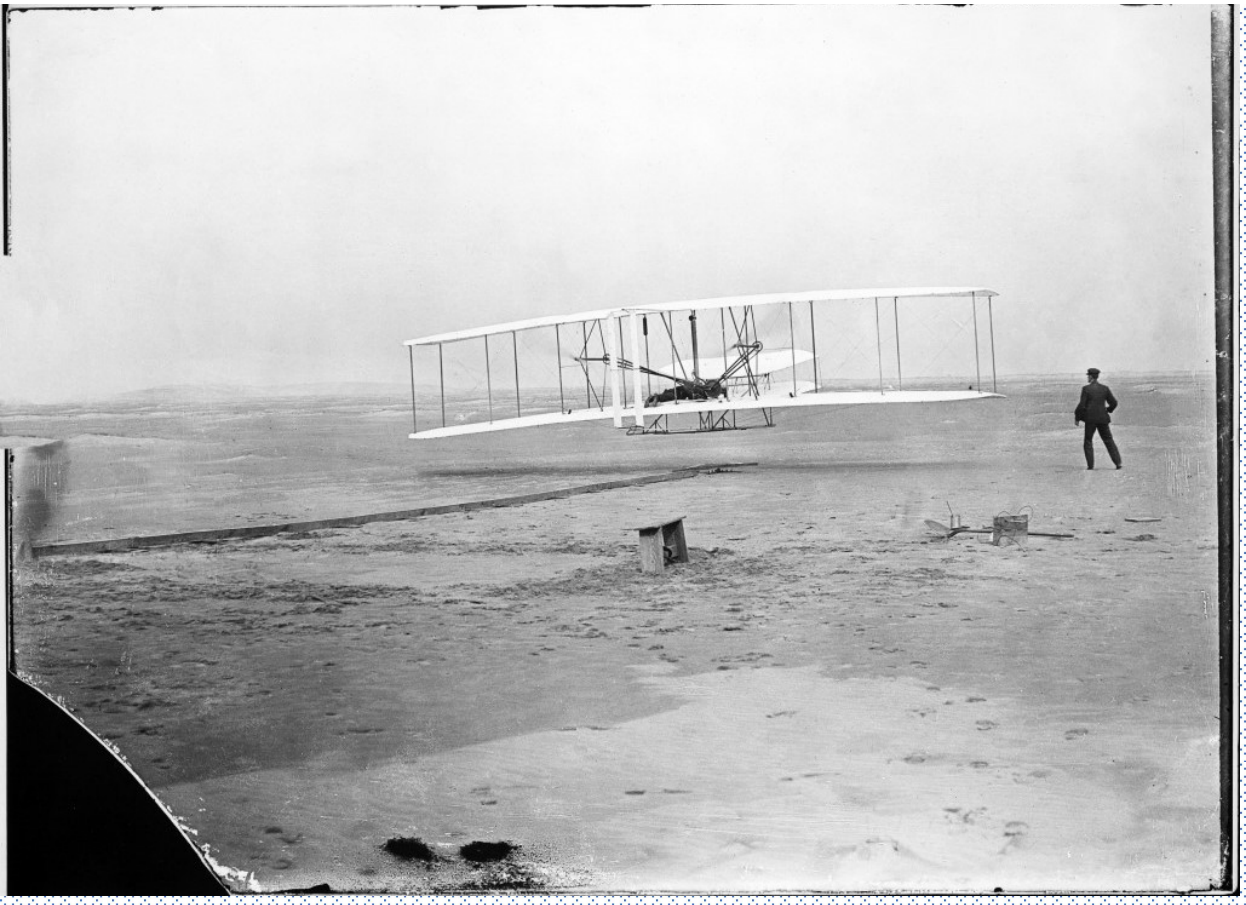


The Langley Aerodrome
NASA Langley Research Center 4/11/1990 Image # EL-2001-00462

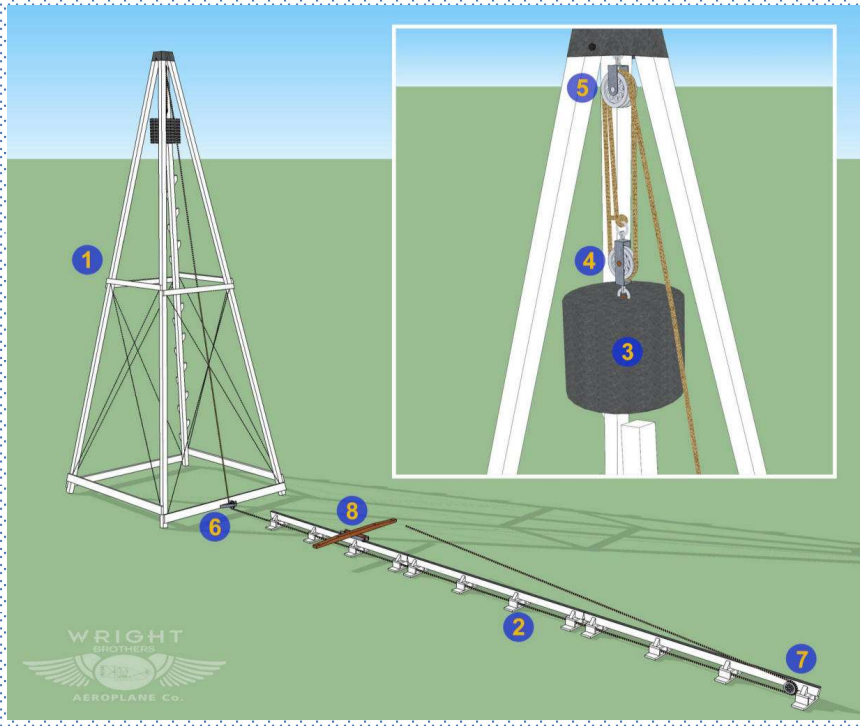
Samuel Langley's prior scale model *Aerodromes* flew well, but the full scale maned version of 1903 did not. Langley blamed the spring launch catapult for the failures. After major modification to the aircraft, it flew successfully in 1914, to try to win a patent dispute with the Wrights.



First of two failed flights 1903. On the second the rear wings failed.



Wright Bros 1903 – a few days after Langley's failure.
See the launch rail – falling weight catapult



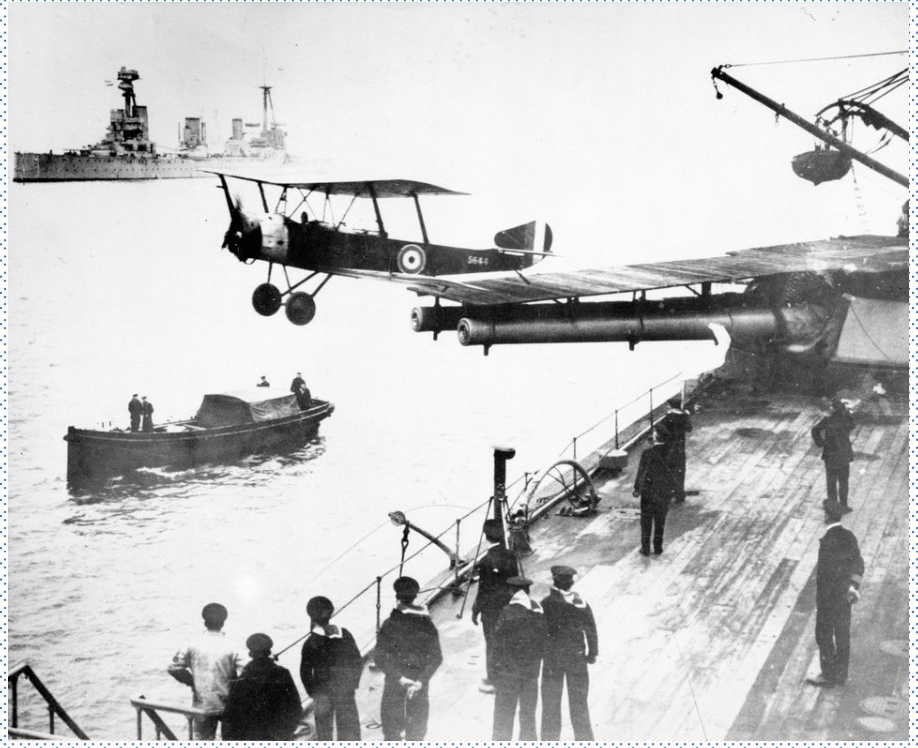
Wright Bros catapult arrangement – used for quite a few years on different models of *Flyers*.

Naval Aviation

Early naval aviation was often land based, but float planes with dedicated servicing ships were an early mode. The planes had to be offloaded to be used and rarely in open sea. Balloon Carriers likewise were of limited utility at sea.

In 1917 a **Friedrichshafen FF 33E** floatplane from on board merchant cruiser SMS Wolf overflew NZ several times. She laid mines.

Early sea launching of wheeled planes was from temporary platforms on warships, or towed barges.

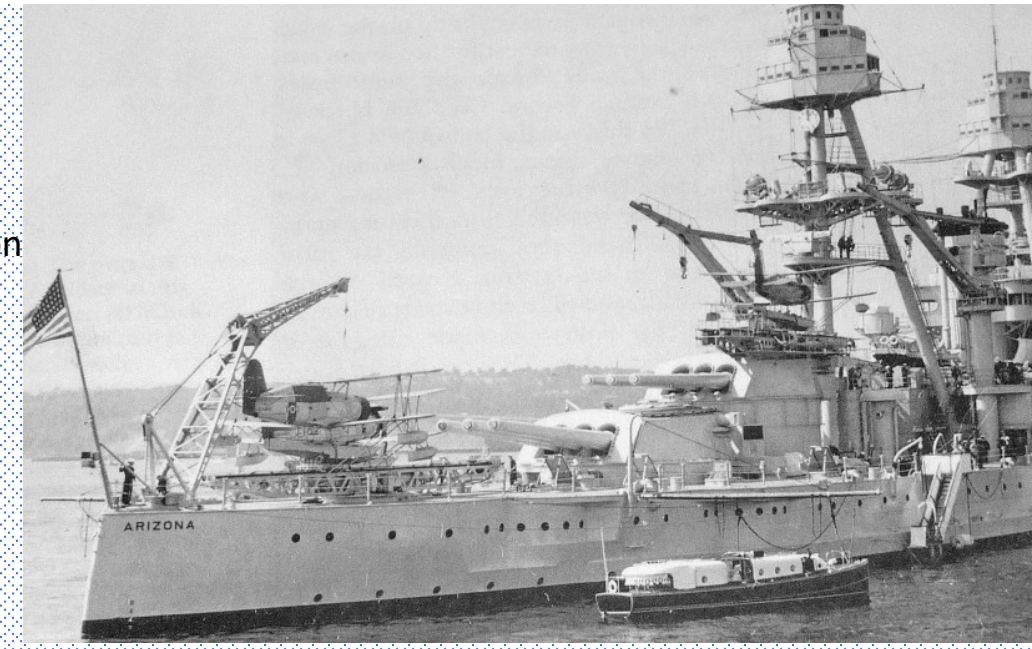


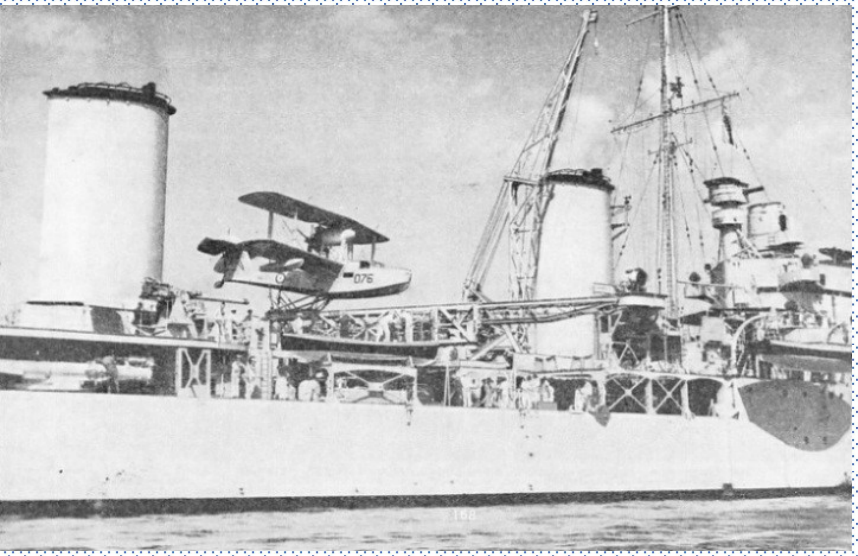
Sopwith 1½ Strutter launching for HMAS Australia

Sopwith Camel take-off from towed lighter – was used operationally – briefly.

Naval Catapults

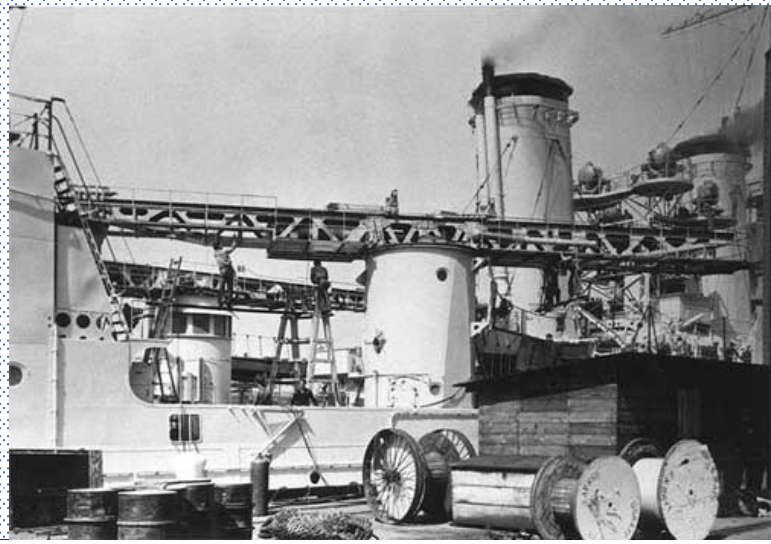
USN had a compressed air catapult in 1912 – land based
Rapidly developed after WW1 for battleship / cruiser application
Experimental / training catapults on shore
British / US / German / Italian / Japanese navies all pursued.



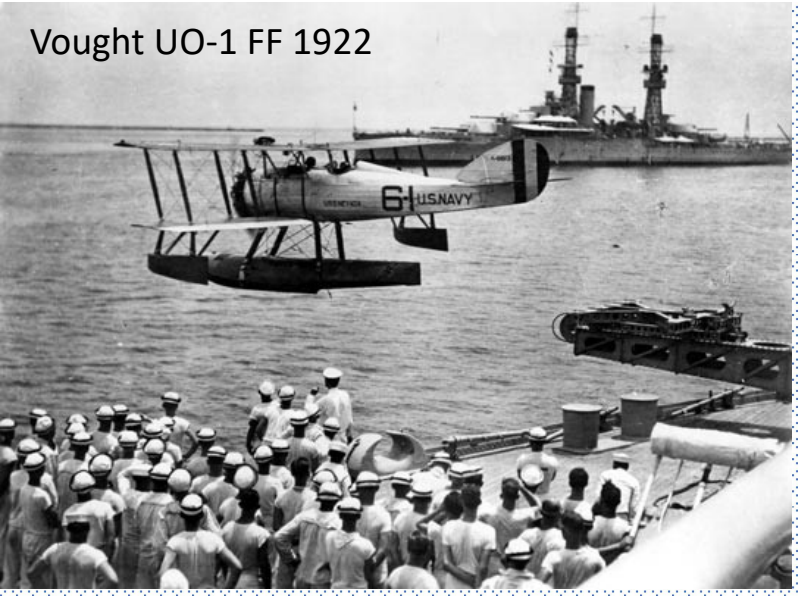


British ships typically had midships catapults – Transverse launch. Cordite charge.

US ship catapults
– some midships transverse
– some C turret top
– some stern.



Vought UO-1 FF 1922



US Catapult Planes - strong preference for single float.
Not amphibious.

Vought OS2U-Kingfisher FF 1938

Curtiss-Wright SOC Seagull FF 1934

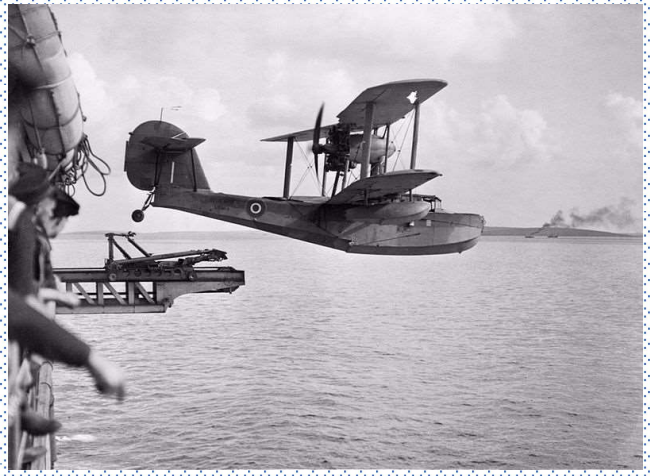
Curtis-Wright SO3C Seamew FF 1939

Curtiss SC Seahawk FF 1944

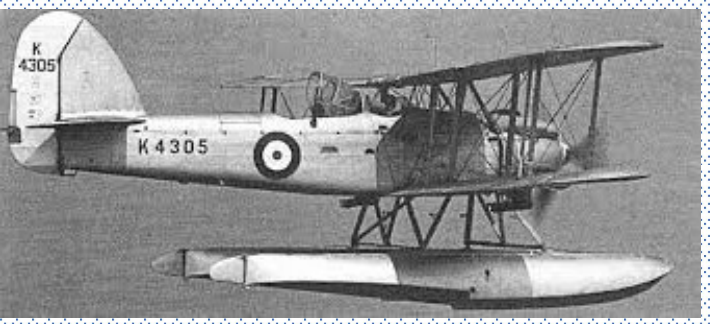
Fairey Flycatcher –
floatplane version. FF 1922

British Catapult Planes

Moved away from twin floatplanes towards amphibious flying boats



Supermarine Walrus. FF 1933 – designer R. J. Mitchell



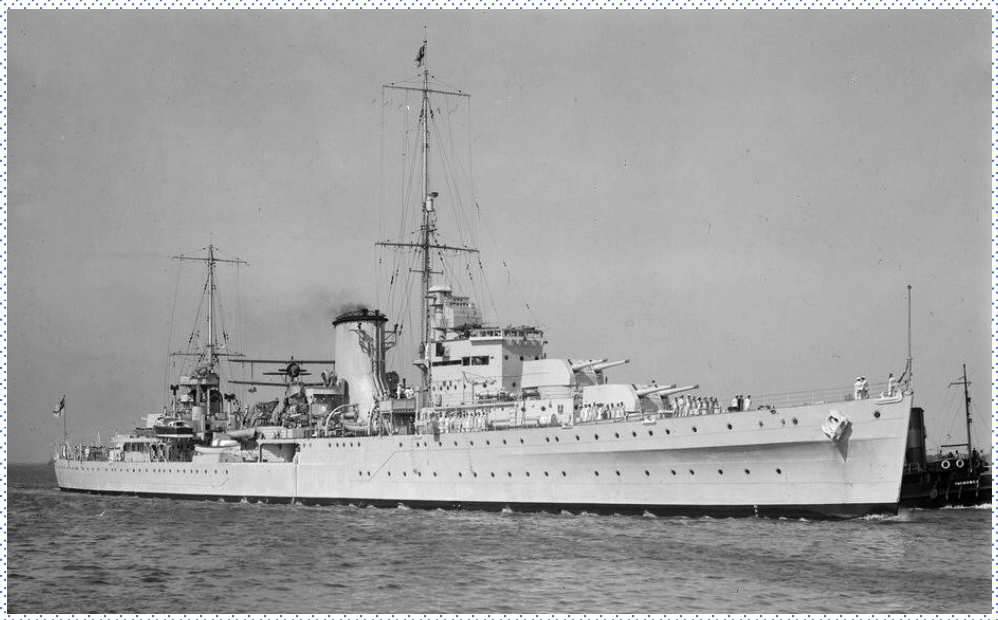
Fairey Seafox.
FF 1936

Supermarine Sea Otter. FF 1938 – designer R. J. Mitchell
Was catapult launchable but catapults went out of service as it was introduced in numbers

New Zealand light cruisers HMNZS Leander and Achilles both shipped float planes for scout / observer roles.

Initially Fairey Seafox (Leander) then Supermarine Walrus (both)

Aircraft seem to have been dispensed with later in WW2 – possibly because they were commonly operating in groups with carriers, but also when radar ranging supplanted fall of shot reporting.



Achilles

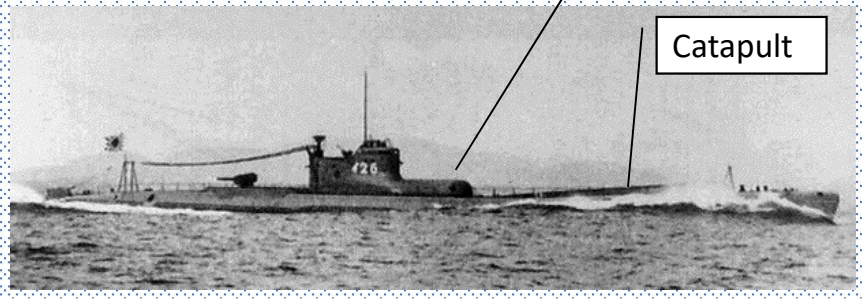
Battle of the River Plate:
Admiral Graff Spee aircraft out of commission.
HMS Ajax launched an aircraft (Seafox) which helped with fall of shot reporting.

Bizarre Naval Aviation

Japan – Submarine carried float planes.

Other nations trialled but only Japan operational.
Largest subs could carry three.
On 8 March 1942 one photographed the Allied build up in Wellington harbour, launched from the Japanese submarine I-25. On 13 March it flew over Auckland.
On the night of 24/25 May 1942 another flew over Auckland from the Japanese submarine I-21.

Yokosuka E14Y
"Glen" Could carry small incendiary bombs



Type B1 Submarine

Germany – Submarine towed autogyro

Focke-Achgelis Fa 330 Bachstelze Unpowered "kite".

Flew at an elevation of 120m – visibility increased from 5Nm from the sub, to potentially 25 Nm

CAM ship - Catapult Aircraft Merchant Ship

Rocket powered launch trolley – solid fuel

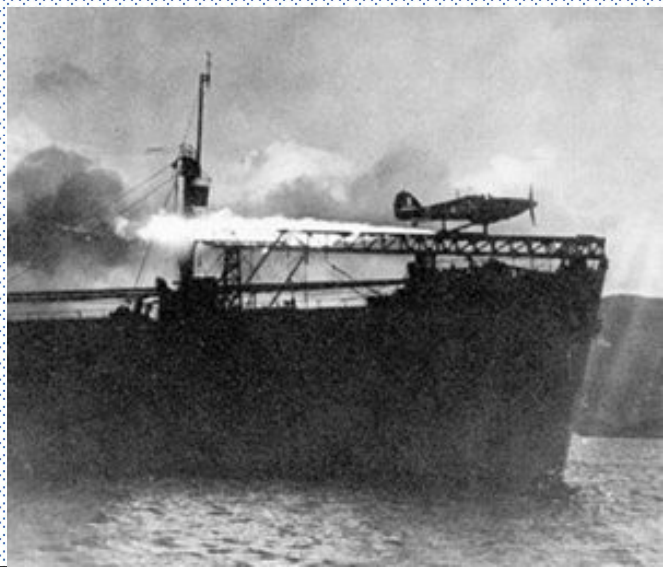
No recovery system

Hawker Hurricanes – of high time – some ex Battle of Britain – sometimes called Hurricats.

Aim was to discourage German Condor patrol aircraft which were effective in passing shipping intelligence to U-boats

35 ships equipped – 8 launches made in anger, 6 aircraft shot down

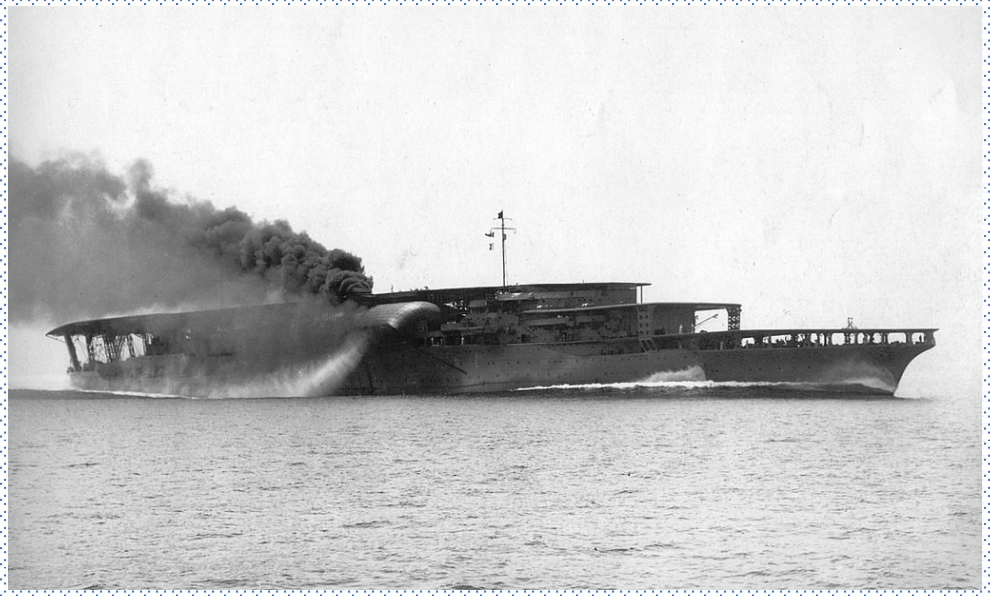
Phased out when escort carriers became available.



V1 Launch Ramp – Assist by piston in slotted cylinder.
Initial sites had steam power – later ones by an “apparatus known as a *Dampferzeuger* ("steam generator"), which reacted stabilised hydrogen peroxide and potassium permanganate (*T-Stoff* and *Z-Stoff*), …”

Naval Aviation - Carriers

Early aircraft carriers did not use catapults – take-off was engine only (sometimes from multiple decks)



Akagi on trials 1927

HMS Courageous

Naval Aviation - Carriers

Hornet CV-8 launching the Doolittle raid of B25s

CV-6 Enterprise with a massive air group

Naval Aviation - Carriers

USS Enterprise, CV-6, a pre-war carrier, had two flight deck hydraulic catapults and one hangar deck catapult.

US developed compressed air catapults Essex Class carrier (CV-9 upward, 1941 on)
- had one or two flight deck catapults
– one hanger deck catapult thought useful for launching scouts when forward deck fouled by recovered aircraft. Radar reduced the need - removed in 1944 refits.

Naval Aviation - Carriers

USN WW2 Deck Catapults

Not used for all deck launches – only when the deck was crowded and there was less take-off length available for the aircraft at the front of the deck.

Post-war:

- Aircraft became heavier, early jets had limited power, war loads were higher - all drove catapults to being essential
- Smaller British carriers were especially constrained. Britain took the lead in developing steam catapults – now the standard. (Steam has more energy to deliver than compressed air at the same pressure).
- The charge of steam released to the catapult varies by aircraft type, all up weight and wind over the deck.

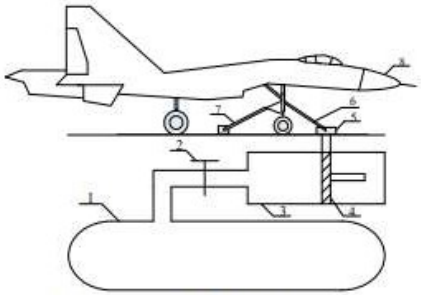
Douglas A-3 Skywarrior

First flight 1952. Heaviest ever carrier aircraft. MTO Weight 82,000 lb.

Designed as carrier based strategic nuclear bomber. The early A-Bombs were very large. The US Navy was determined to rival the Air Force in the strategic role.

Drove the need for both larger carriers and powerful catapults. The new carriers were bitterly opposed by the Air Force.

In the event A bombs became smaller, the Navy decided on submarines for its primary nuclear strategic arm and the A-3 *Whale* served out its time in tanker, electronic counter measures and reconnaissance versions.



1– *Accumulator*, 2– *Launch valve*, 3– *Cylinder*, 4– *Piston*
5– *Shuttle*, 6– *Launch bar*, 7– *Holdback bar*, 8– *Aircraft*

Launch Bar
Part of Aircraft

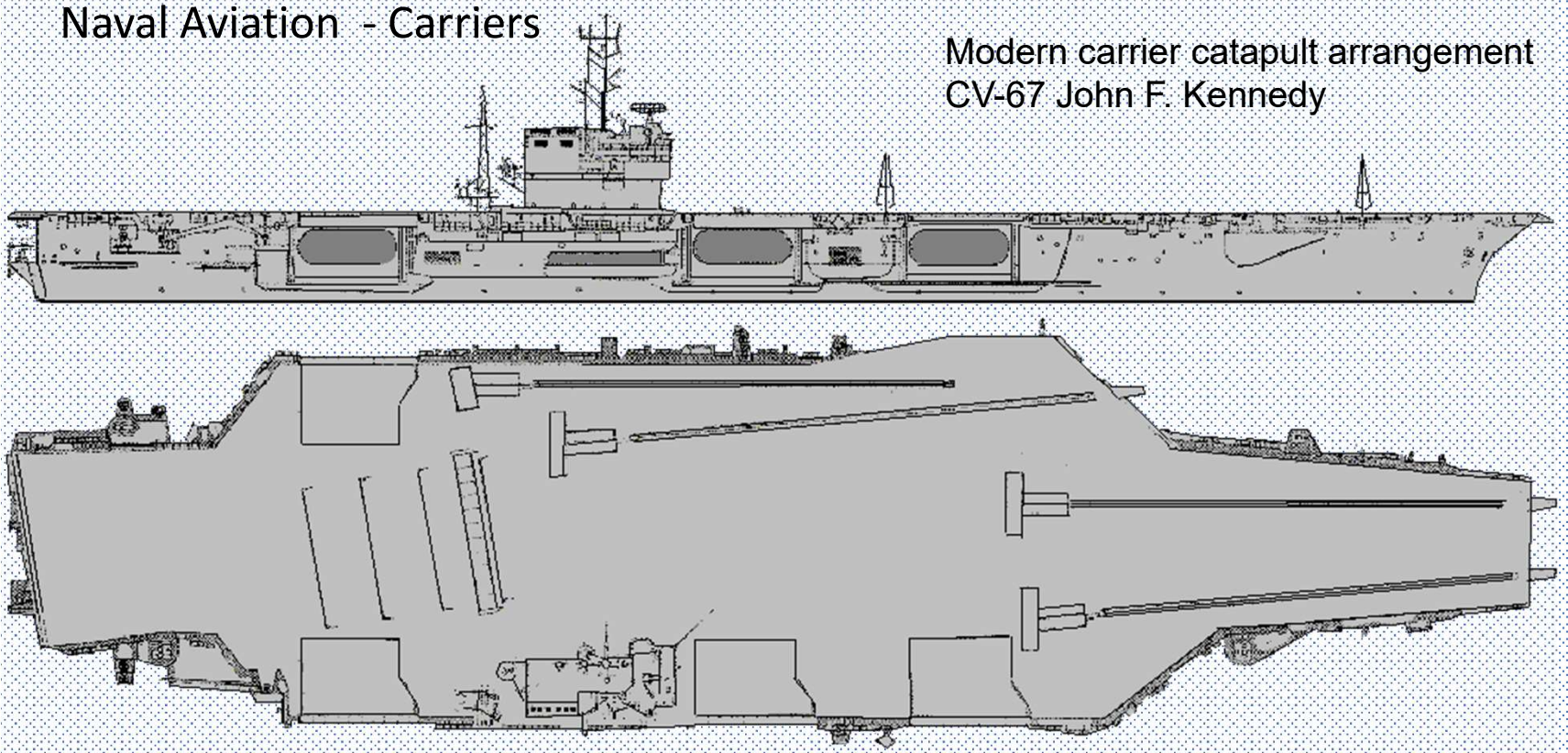
Holdback Bar -
frangible element

Shuttle – connected to piston

Sequence is: Holdback bar fixed to ship, Launch bar hooked to shuttle, Steam pressure brought up to needed for the aircraft and its load, while the piston is locked. Engines spooled up to take-off thrust, Piston released, Holdback bar frangible bit breaks and releases under the combined load.

Naval Aviation - Carriers

Modern carrier catapult arrangement
CV-67 John F. Kennedy



Routing steam from the engine room – a risk in a damage situation in war-time, and penetration of containments for nuclear powered ships.

Gas turbine powered ships had to have a steam generator to power catapults.

Electromagnetic Aircraft Launch System (EMALS)

New technology to supersede steam catapults
Uses linear induction motor
Draws from energy storage - stores energy kinetically using the rotors of four disk alternators; the system then releases that energy (up to 484 MJ) in 2–3 seconds, 45 second recharge.
EMALS weighs less, is expected to cost less and require less maintenance, and can launch both heavier and lighter aircraft (e.g. UAVs) than a steam piston-driven system.

Developers USN, reportedly China, considered by UK – for Queen Elizabeth class – but rejected, India undertaking development studies.

Installed USS *Gerald R. Ford* (CVN-7) – First of class, commissioned but not yet deployed.

Donald S Trump: "Digital. They have digital. What is digital? And it's very complicated, you have to be Albert Einstein to figure it out. And I said—and now they want to buy more aircraft carriers. I said, "What system are you going to be—" "Sir, we're staying with digital." I said, "No you're not. You going to goddamned steam, the digital costs hundreds of millions of dollars more money and it's no good."

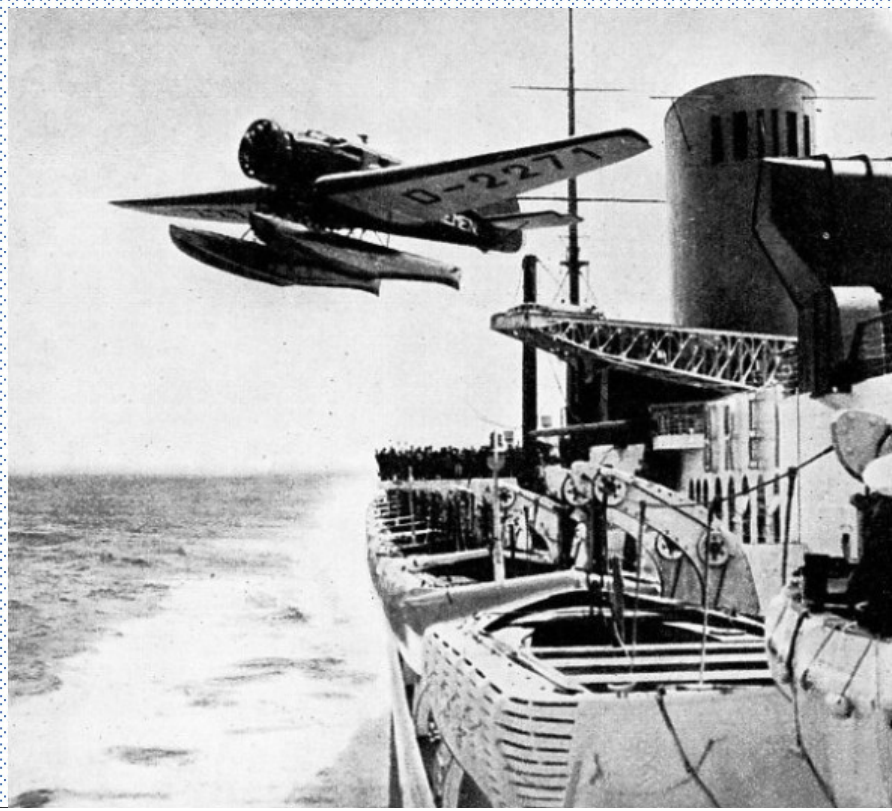
Civilian Catapults – North Atlantic / South Atlantic Mail

From 1929, Norddeutscher Lloyd-liners SS *Bremen* and *Europa* were fitted with compressed air-driven catapults launch mail-planes. These ships served the route between Germany and the United States. The aircraft launched, carrying mail–bags, while the ship was still many hundreds of miles from its destination, thus speeding mail delivery by about a day.

Initially, Heinkel He 12 aircraft were used before they were replaced by Junkers Ju 46, which were in turn replaced by the Vought V-85G.

US Postcard

He 12 launch
from Bremen



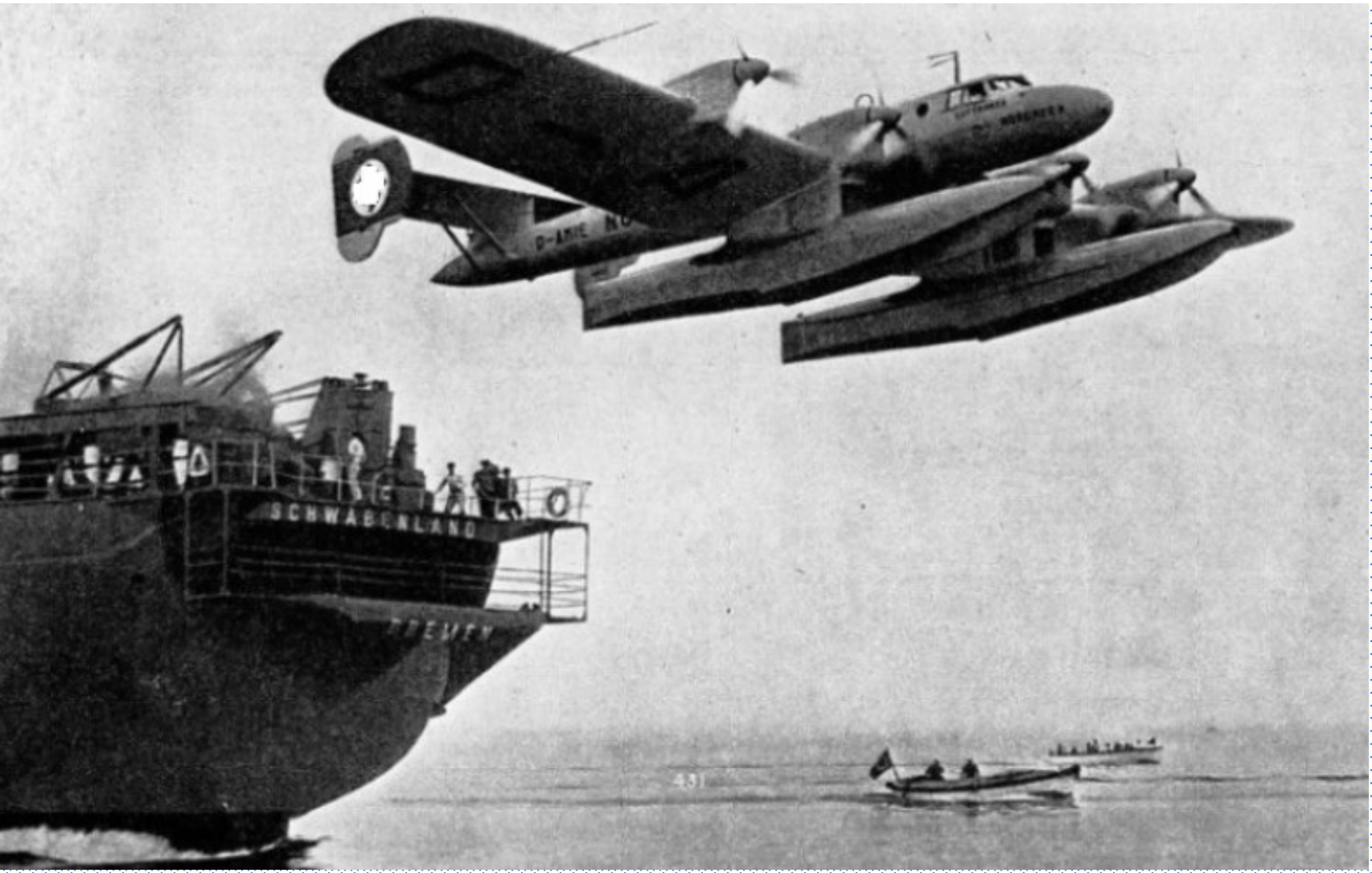
Lufthansa used dedicated catapult ships SS *Westfalen*, MS *Schwabenland*, *Ostmark* and *Friesenland* to launch Dornier Do J *Wal* (whale), Dornier Do 18 and Dornier Do 26 flying boats on the **South Atlantic** airmail service from Stuttgart, Germany to Natal, Brazil.

On route proving flights in 1933, and a scheduled service beginning in February 1934, *Wals* flew the trans-ocean stage of the route, At first, there was a refuelling stop in mid-ocean. The flying boat would land on the open sea, be winched aboard by a crane, refuelled, and then launched by catapult back into the air.

From September 1934, Lufthansa had a support ship at each end of the trans-ocean stage, providing catapult launchings after carrying aircraft out to sea overnight.

Dornier Do.18 flying boat on Schwabenland's catapult

MS *Schwabenland*



Blohm & Voss Ha 139

Catapult Airmail Philately

Naval Aviation

Need for airborne coverage

- "Fall of shot" reporting – Catapult equipped ships.
- Scouting – extend the range coverage against opposition surface naval forces - with better coverage than picket ships – Relevant to Carriers and catapult equipped ships.
- Counter opponent scouts - Relevant to Carriers and catapult equipped ships.
- Combat air patrol – to counter inbound airborne attacks and protect outbound strikes – fighters. Later with aerial Radar - night fighters – Relevant to Carriers
- Anti submarine - force subs to operate submerged – early subs were much slower submerged and hence could not readily manoeuvre to torpedo firing positions – bomb or rocket or depth charge armed or later homing torpedo equipped aircraft – sometimes paired with radar and acoustic buoy detection aircraft in hunter / killer pairs.
- Airborne Early Warning – once Radar better developed – could provide better coverage than surface ship radar – eventually airborne command of counter force fighters.

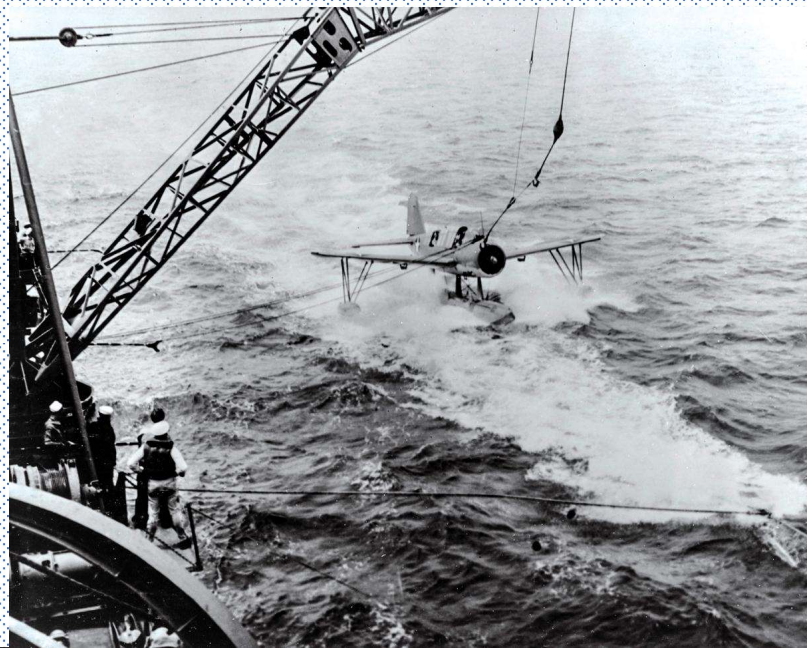
For Carriers, having decks clear for launch and / or recovery is essential to good airborne coverage.

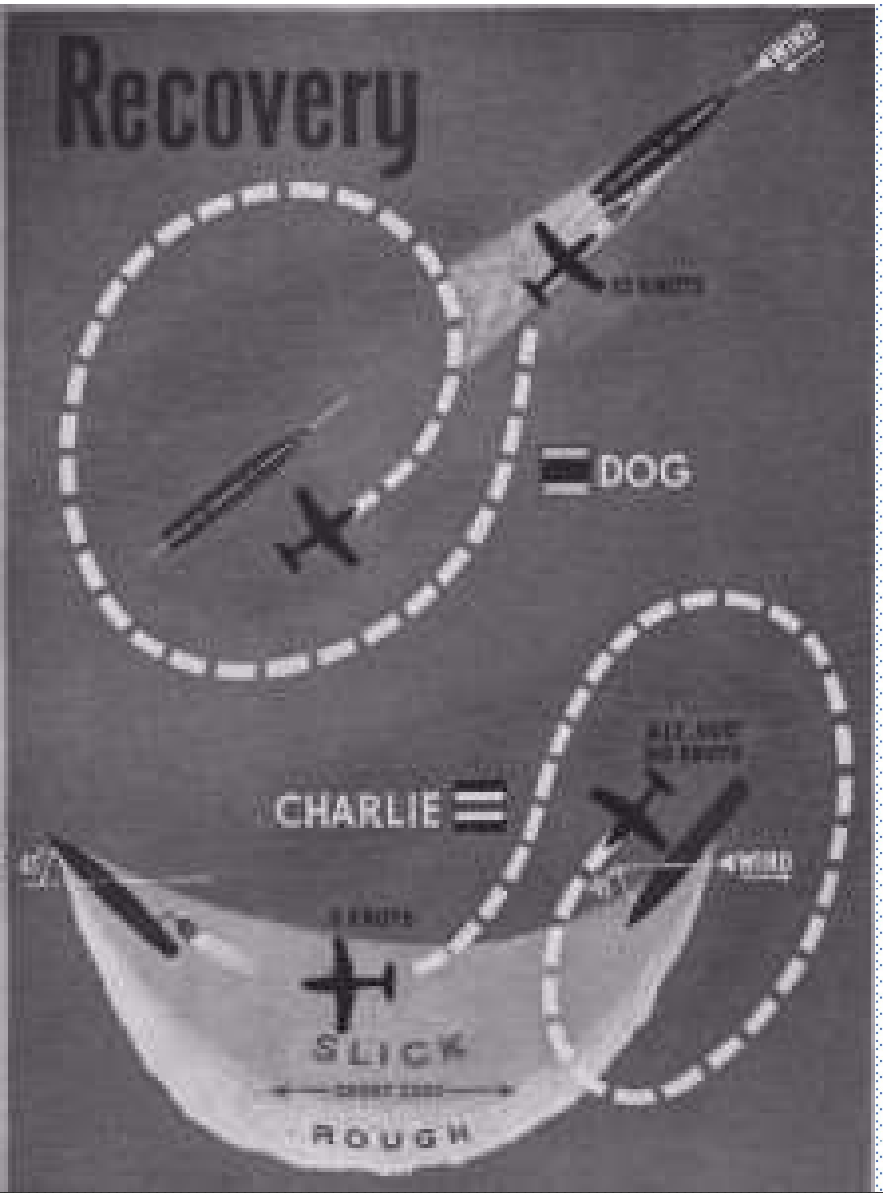
Tactical Constraints

Catapult plane recovery – had to slow and go upwind, within the airborne duration / range of the aircraft.

Slow scout planes proceeding against the wind and the home ship likewise could have a much slower closing speed.
e.g. Kingfisher Scout 132 knots cruise speed. Home ship: heavy cruiser 15 knots cruise speed 32 knots maximum. Moderate Gale 30 knots. 132 less say 25 ship, less 30 wind = 77 knots – a 42% reduction – or a 72% longer closure time

Carriers – needed to proceed upwind for launch and recovery. Before helicopters - needed to include a close escort for downed aircraft recovery – and more generally not to sail away from other ships in group – those being escorted, or part of the strike group.




Recovery
DOG
CHARLIE
SLICK
ROUGH

US Navy and Political Power

Of the first 12 post war presidents, up to Obama, six had served in the navy

Two of them had been naval aviators – a naval elite (Ford and G.H.W. Bush) – a tiny proportion of the US population

Most have USN ships named after them (Nixon, Clinton and Obama are exceptions)

Carriers are often named after presidents

Carrier names are:

Franklin Delano Roosevelt	CV-42
Theodore Roosevelt	CVN-71
Dwight D. Eisenhower	CVN-69
Harry Truman	CVN-75
John F. Kennedy	CV-67
Ronald Reagan	CVN-76
George H.W. Bush	CVN-77
Gerald R. Ford	CVN-78

5 Republicans, 4 Democrats

Modern carrier strike group - posed for photo – not a normal sea deployment
Sometimes a carrier group has two carriers.

POWERFUL
MOBILE
FLEXIBLE
INDEPENDENT
SUSTAINABLE

The Strike Group is composed of the right combination of ships, submarines, aircraft, and personnel to support an extensive range of operations from wartime combat to peace time presence. The Strike Group provides the credible warfighting capabilities necessary to influence the battle space from the ocean floor to space.

TOTAL CONTROL OF THE SEA AND AIR
Coordinated network of sensors, weapons systems, data sharing and intelligence fusion to defend against enemy aircraft, ships, submarines, cruise missiles, and ballistic missiles.

STRIKE
Plan, direct, and execute overland strike missions using large quantities of land-attack missiles and precision-guided weapons launched from aircraft, ships, and submarines.

COMMAND AND CONTROL
Robust, resilient networks that provide real-time intelligence necessary to make decisions and adapt in a rapidly changing environment.

ELECTRONIC WARFARE
Dispersed system of sensors, intelligence gathering, and active electronic warfare equipment delivers situational awareness for U.S. forces while denying the enemy any advantage in the electronic spectrum.

CYBER WARFARE
Provide defense against attacks and deliver tactical advantages in the cyber realm.

LOGISTICS
Efficient transfer, handling and storage of parts, fuel, weapons, and food. While the carrier offers sufficient supplies for weeks of operations, the system relies on replenishments at sea to enable even longer station times.

Zero Length Launch (ZELL)

Rocket launch systems – solid and liquid – developed by US, West Germany and USSR but not deployed.
Thought of as a method to overcome airfield denial weapons – but where would they land if runways were damaged?
One time use rockets would have meant a high practice cost.

Republic F-84
Thunderjet

North American
F-100 Super Sabre

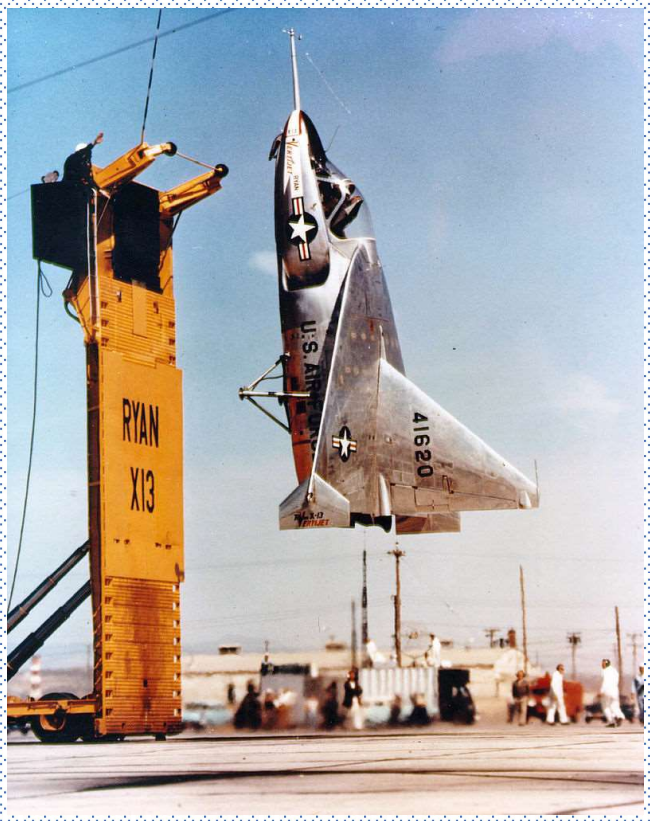
Lockheed F-104G
Starfighter

MIG-19

Early USN VTOL Attempts

Convair XFY-1

Lockheed XFV-1



Ryan X-13

Ski Jump Carriers - no catapults

Invented by the UK for **Harriers** but since used by Italy, India, Spain, Russia, China.

Russia: Sukhoi Su-33 Short Take Off But Arrested Landing - STOBAR

China: Shenyang J-15 – in part reverse engineered from an Su-33 obtained from the Ukraine. **– STOBAR**

UK Just regaining the ability with *Queen Elizabeth* **Short Take-Off, Vertical Landing - STOVL Lockheed Martin F-35B Lightning II**

Russia and China building no more ski jump carriers – future Chinese ones to be conventional to allow greater launch weights and hence air to air buddy refuelling.

Invincible Class 22,000 tonnes

Queen Elizabeth 65,000 tonnes

JATO – Jet Assisted Take Off

Used liquid and solid fuelled rockets

Germans did a lot of development / trials in WW2 but only marginally approached application

US developed solid fuel system in WW2 – commonly applied it afterwards. NATO Standard.

Used for:

- Early jet aircraft which were commonly underpowered by todays standards
- High drag surfaces – e.g. skis on snow
- Tactical needs to boost payload / shorten take-off length.

Early De Haviland Comet aircraft had two jet fuel / hydrogen peroxide-powered de Havilland Sprite booster rockets for hot and high conditions – trialled but not used operationally.

The Boeing 727 had provision for Aerojet JATO assist for use in hot and high conditions, particularly at Mexico City and La Paz.

Water injection, used for take-off on many early jets to overcome hot and high, was the common solution rather than JATO.

B47 Stratojet

Were used by USN aircraft departing NZ to Antarctica in the 1950s during Operation Deep Freeze.

C130 Hercules

RNZAF Herks had the fittings for JATO but have apparently never used them.

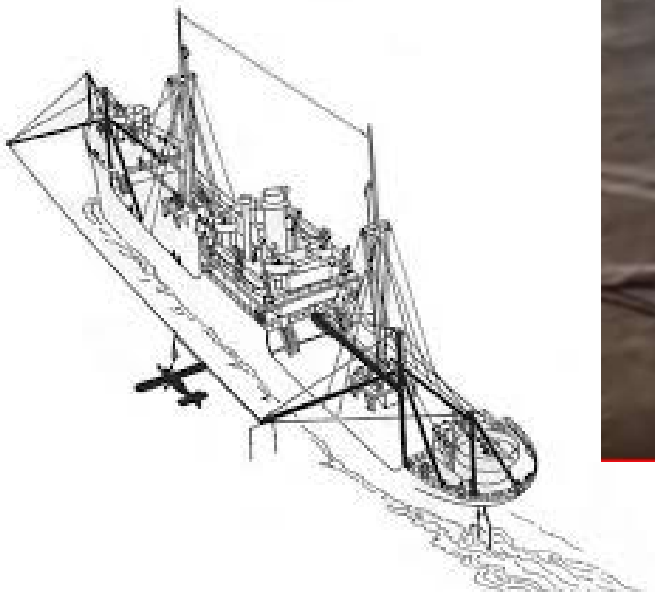
Boeing 727

Brodie Landing System

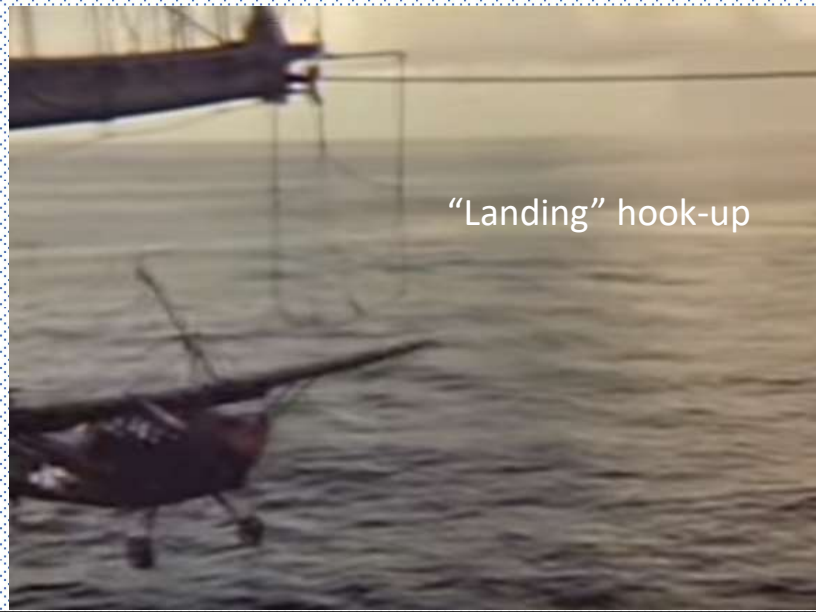
(and take off)

Developed in WW2 by US Army and deployed by them and UK army onshore and the USN on two LSTs.

Stinson L-5 Sentinel, Piper L-4



Take off – just after release



"Landing" hook-up

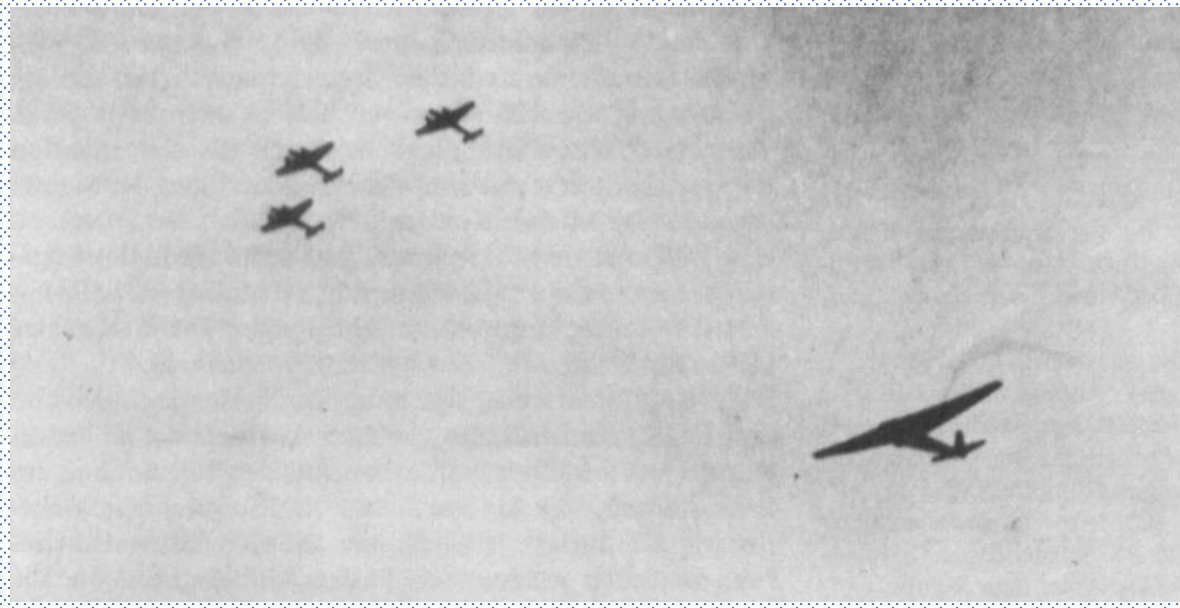
Military Gliders

Towed off the ground to release point by powered aircraft

Sometimes two gliders per aircraft

Germany: Me 321 Gigant Glider towed by three Me 110 aircraft, later conjoined He 111s.

C47 with two CG-4 WACO assault gliders



Gigant with Me 110 tows

Civil gliders: aircraft, winch and bungee launch.

END

To come:

- Carrier Landing and Deck Organisation
- Parasite Aircraft
- Flying to and in the Antarctic - from NZ